

GEO. GEOLOGY I



**FOUND
AS
SCANNED**

7 what are. oldest known fossils

branches of animal kingdom are represented by Cambrian fossils

what is geologic date (period) of oldest known reptile
bird primate placental mammal, mammal and
anthropoid.

Essay on Oithogenesis - evolution. Ascent of air breathing
vertebrates from water.

arguments as to descent from unicellular organism
of Precambrian.

Pleistocene Glacial History of N. America + Europe
sequence of glacial stages + location of ice sheets + glaciers

Geographic relations of the several continents i.e.
land connection or sea barrier during Periods of quaternary
+ Tertiary - How did these relations effect history
of land mammals.

Principal metallic ores found in N.A. in Pre Cambrian - where
diagram + explanation of why between Grenville line
and Timiskamian rocks.

N.A. during Pennsylvanian measures a Triassic rocks of Corn
Valley

Pre Cambrian
Camb
Penna
Triassic
Tertiary.

St Petersburg Fla
Grand Canyon Inner Gorge
Pittsburg Penna

Ordovic.
Devon.
Miss
Jurass
Tertiary.

Yosemite
Yellowstone Park.
Cincinnati

Pre Cam
Cam
Ord.
Triass
Cretaceous

Hartford Conn
Pulaski Minn.
Nashville Tenn.

Saffrey,

Wherever you're down
with your notes don't
forget your old pal Johnny
upstairs. Thank you. W

J.C.R. P

how does

attempt to

Planetesimal Theory — account for structure of earth's interior which seems indicated by modern geophysical investigations

possible explanations of glacial climates of past

Compare & contrast N.A. — in mid Cretaceous period
Mississippian to sea, land & mountain regions
same — early Tertiary & Triassic.

Compare & contrast Pleistocene & Boreland glaciation
origin of life & origin of vertebrates

● Geologic history — of
Proterozoic.

camel tibiae

kinematics

ammonoids

angiosperms

future of earth as a home of man. — in light of past

● Look up final 38.

Mather - May 22

VIII Monkind

(common ancestor.)

- 1) Early Tertiary primates - Notharcus
- 2) Anthropoid development toward modern types
- 3) Archaic hominidae
- 4) Advent & progress of genus homo.
- 5) Homo Sapiens

IX Toward an understanding of organic evolution.

- A.) Fossil testimony
- B.) Origin of life
- C.) Mechanism of heredity
- D.) Origin of species
- E.) Geologic factors in organic evolution.

X Earth hist. & man

- A.) Man & animals
- B.) Man & prospects of geologic change

XI Facing the future

Order
Primates

Suborder, anthro-
poidia

~~Monkeys~~

Eocene & Pliocene, primitive animal-like primate.
Primates have nails, different skulls. Omnivorous. Tail.
Skull - (Notharcus) ^{oldes primate} Ascending ribs? Gibbon most
primitive modern anthr. Apes & man all from Notharcus.
Progress is towards ^{2nd} ~~1st~~ recession, development of chin.

1st modern anthropoid, Oligocene, Egypt; Miocene, India,
ancestor of man, chimp, Gorilla, orangutan, not of others. (All)
~~ancestral to man & chimp~~ Miocene, 1st thing that was
ancestor of man only. - *Sitona pathicus*. Then development
toward wider jaws, accompanying bigger brains. Wider jaw
means parallel sides, & are in front. This explains man's great
ability to make variety of sounds, with broad, flat tongue.
Also, there must be cavity below tooth line. This explains
human chin - it makes room for tongue. Pliocene -

Hominidae X. We do not know which is oldest of family, hominidae, early Pleistocene. 1) Java, DuBois, 1892. - femur, large brain. teeth, & skull-cap. - Pithecanthropus 2) Rhodesia - face 3) Sinanthropus, 20 found, definitely hominidae. 4) Pittedown, Sussex, eoanthropus. Simultaneously, flaked flints made. This in terminal moraine of last glacier, in driftless S. Eng.

homo Next, first genus homo. Heidelberg jaw, Homo heidelbergensis. Quite primitive, massive, powerful jaw, mid Pleistocene. Late Pleist, homo Neanderthalensis, the cave man. Fire & flints, co-operated in bands, overcame mammoths. lived 150,000 years.

Sapiens Species - Cro-magnon man, 30-40,000 years ago, W. Eur. Artists. Brainier, not more muscular.

Continuity of land, n. hemisphere. Hominidae developed. Caspian sea, waves of migrants. Negroids, Australoids, Mongoloids, Caucasians - this 2,000 years ago, then Caucasians spread. Differentiation of races accentuated by segregation.

Minnesota girl, '37, 1st Mongol in America. 18-20,000 years ago, Wisc. ice still there.

IX Sequences of life proved. Beginning of Cambrian, lines are cut off, but they converge, if tendency could be continued they would come to one. I.E.



Origin - synthesis. (Impossible today, due to bacteria.) Locality - moist ground.

Why has it improved? - Offspring are different, not better. Selection does it.

Mutations. Geologic factors do selecting. (?) But man not dependent on environment. No Malthusian fear necessary.

Synthesis of superman coming up, from meeting of various groups, best traits of each group.

Mathur - May 20

VIII D Mammals

1) Of the Mesozoic

- a) Origin from mammal-like reptiles
- b) Egg-laying & marsupial mammals.
- c) First placental mammals in Asia during Cret. time.

2) Widespread dominance during Cenozoic Era, the "Age of Mammals".

- a) Archaic creodonts & modern carnivores.
- b) " condylarths & " hooked herbivores

Amblypods ~~herbivores~~ victims of Megalomamias
Odd footed, hooked mammals.

Even footed " "

c) Proboscideans.

d) S. Am. side lines

e) Mammals invade sea & air

3) Beginning of decline in Pleistocene E. Mammals.

Triassic. Permian, Texas, & S. Afr. 2 groups of mammal like reptiles. N. Am. ones failed utterly. S. Afr. ones succeeded, early Mesozoic. Triassic - dog like posture, diff. teeth, legs under him, small tail. - But also is reptile like - 2 distinct - blood & breasts, neither in skeleton. Not all mammals were, but have mammary glands. Then Comanchian, N. Am., & Afr. & Asia, jaws with mammal characters, born teeth & articulation of bone. May have been egg-laying, maybe marsupial. Placentals, Cretaceous of Mongolia, only Mes. one Osmosis, oxygen thus transferred thru placenta. Small, unable to tick dinosaurs. But, Cretaceous end, all dinosaurs extinct, because other values than militarism counted most. Mother-love was it. Patrio filis, creodont, ancestor of cats, but untractable claws, not such cutting teeth. Then cats, sabertooth tiger, exten-

Bring note books to final, there will be questions on them

Theromorphs

in killing, best thing ever. But now extinct, it overdid something, don't know what. Present cats less dread ful.

Herb

Archaic hooked herbivorous condylarth, when? ().

1. Got bulkier & bulkier, for protection, flat foot, ambulator. Then bony projections. Megalomamia. Now extinct.

Closely related, lighter limbed herbivores, still living. 2

2. groups, 1: hooked (like horse), 2 hooks (cow, "claw hoof")

Eocene ehippus, 3 & 4 toes. High arched back, very small, size of fox. Oligocene, 3 toes. ^{woodland} Miocene, prairie, had to get fast starts from cats, got up on toes. Equis scotae, bigger than modern horses, faster, too. Extinct now. (Why?)

Camels started in N. Am., on toes like horse. Hind feet evolve faster than front. Bones fused together, "common bone" formed. Horse has "common bone" too, from different bones.

Late Miocene, Llamas etc., moved to S. Am., & some to Eur. & Asia. By Pleist., died in N. Am.

Elephants. Pleistocene hairy ^{mammoth} ~~mammoth~~ mastodons different, there too. Imperial elephant ancestor of modern. N. Afr. Mammot like elephant. Mastodon teeth like humans, elephant teeth different. Ice killed 'em.

S. Am., Paleocene, only herbivores migrated, no cats. Marsupial cats were there, they competed. Armadilla, mammal turtle.

Giant ground sloths. Late Miocene, new Isthmian bridge, inter migration horses to S. Am. (Air & water mammals. Bats, which have to hide, birds use air. But in sea, warm blood better than cold.) S. Am. herbivores slaughtered, some got north, & to Europe. Then ice age drove everything south, they stayed there, horses driven from Americas, all animals have declined in Pleistocene, except man.

Mather - May 18

VIII C.

3 Dinosaurs, rulers of Mesozoic

4. Preptiles conquer the seas (Plesiosaurs, Ichthyosaurs)

5. Preptiles invade the air - Pterosaurs

6. Modern reptiles, remnants of a vanquished army

7. Origin & evolution of birds

D. The Mammals

Triassic redbeds of Conn. valleys fossil footprints, Stegonis, legs under him, small feet. Bigger, $\pm$ foot feet, semi-erect stature. 3rd kind, Podoposaurus, bipedal, long whiplash tail, a weapon. These 3 are beginners of dinosaurs. Jurassic, 2 major groups, Carnivorous bipedal, with teeth, powerful claws. Climax, Tyrannosaurus rex. Legs, strength & flexibility mixed. Very long heel, walked on toes. Long, massive, tail, typical of carnivorous dinosaurs, a handicap. 2) Herbivores, slow & stodgy, quadrupedal. Brontosaurus. Pad like feet, like elephant. Heavy legs. Mammalian articulation. Being cold blooded, needed less food. Small brain, & nerve ganglia in hips larger than brain. Deplodocus carnegiae. Tails for defense. Other herbiv. Stegosaurus, bony scutes along spine, prongs on tail, small head. Triceratops, no teeth, but parrot like jaw. Horns not deciduous, but part of skull. Their eggs, in Mongolia, Cornmanchean. How do we know they are dinosaur eggs - in same strata with dinosaurs, also have little dinosaurs in them.

4. Perfect adaptation by plesiosaurs. Adaptation of legs into flippers retains bone bones. These ain't fins. // Ichthyosaur different. Body fishlike, but still reptile. How about eggs - had to be

hatched in dry. Eggs incubated in body, young born alive.
1st viviparous vertebrate, like guppy. Maybe warm
blooded. Preptiles ruled sea.

5) Pterosaurs, Jurassic, with dark. Pretails, head extension
replaces tail as rudder. 26 ft. wingspread. Could collapse
wings. Little claws on end. One "finger" elongated whole
length of wing. Hollow bones. Not ancestors of birds.

6) Modern reptiles not descended from big ones, but from minor,
inconspicuous, Mesoz. reptiles.

7) Birds. Some leaping, light dinosaurs. Soon became
covered with feathers, Archaeopteryx, Jurassic. Teeth.

Wing - bat, all fingers elongated, Pterosaur, one finger. Archopt.,
joints turned, resembling modern. Some aquatic lost wings.

Tertiary - no teeth, but sternum, breastbone. Late Tertiary,
Ostrich like ~~bird~~ reptile.

VII

13

Fishes & Amphibians

1. Advent of the vertebrates - Anaspid by Silurian.
 - a) The record
 - b) Theories of origin 1) Eurypterid 2) Amphioxus.
2. Developmental Fishes - Anaspid
3. Advent of air-breathing vertebrates from the water

C. Reptiles & Birds

1. Transition from amphib. to rept.
2. Developmental lat. paleo. reptiles
3. at the Mesozoic - ~~from~~

4th subphylum 3 degenerate subphyla, with no fossil record. Craniates, notochord + cranium, classes - cyclostomata, marts. always open, + other 5.

a. ~~Ordovician~~ Ordovician, armor of ostrachodermis, $\frac{1}{2}$ anttho-pod, $\frac{1}{2}$ fish, implying we are descended from eurypterids. Losing external armor, replacing it with internal skeleton, the process. Silurian, tubular body, paired appendages, notochord. Anaspid. (modern amphioxus). 2 theories - 1) armored fishes gradually lose armor 2) Armored fish are degenerated, now acquired notochord + then paired appendages, amphioxus important.

Anaspid, caudal fin, small pectorals, (Missing link is not true + more & beast, but true fish & ancestors, E, Ord. & Sil. Modern lamprey eel, cyclostome, like Anaspid. Devonian, true fish. (Garr pike very primitive) Devonian Ganoids (1st seen since mesozoic pulled up 6 years ago). / Thing with $\frac{1}{2}$ armor is ostrachoderm. Devonian - Pronghorned ganoids, sharks, armored, & ancestral lungfish, dipnoids. (Ord, 1st ostrachodermis) Accessory breathing organ, to take care of change in water volume. - They live for months, hibernating above water. Lungfish of Devonian, when great anoxia may have become land animals, driven by such necessity. Miss. Amphibians. Lungs had to be protected, & organs of locomotion. Humans, rodents & oliv bones.

Legs replace fins both structurally & functionally.
Femur, tibia & fibula. But lungs don't replace gills
structurally - gills became inner ears. Lungs came from
air bladder. Stegoccephalium, Perm. amphibian.

Amphib eggs require water. But reptile eggs do not. Permian,
many reptiles. Fin-backed lizards, soon extinct. One reptile
goes back to water, with webbed feet. Thero morphs, foreshadow
mammals, with differentiated teeth, like mammals, & legs under them,
one group in Africa, one in Am.

Mather. May 13

VIII A.

11. b. Gastropods of sea & land - Snail, on land by Silurian

c. Cephalopods - chambered.

Successful nautiloids - Ord.

Rise & fall of ammonoids (order) - Triassic & Jurassic

12. Arthropods

a) Trilobites, intelligent but unsuccessful

b. Scorpions & eurypterids. - Spiders by Permian.

c. Crustaceans of the modern type - by Jurassic

Modern ass. by Tertiary. Insects ancient & modern - Penn. cockroach, dragon fly

B. ~~Ar~~ Fishes & amphibians. - ~~Ordovician~~ ostrachoderms.

11 b Snail - part of digestive stuff in foot. Eyes, mouth, head, nervous system. Aware of things far from body. The shell interests the geologist. Spiral chamber, just one. Siphuncle, tube thru shell to take in liquid. Early paleozoic, 2 kinds. - Those in spires, & those coiled in single plane & vertically symmetrical. ~~Permian~~ Mesozoic, siphuncle tubes, like modern. Modern gastr. are freshwater & air-breathers both. There were Sil. land snails, oldest known air-breathing animals. There are post-glacial arthropods. - Capulids, because shell is shaped like liberty cap. Siphuncles only found in warm waters.

c. Cephalopods - there are modern forms. Shell coiled like gastropods. Eye, mouth surrounded by tentacles, carnivorous, Chambered.

As Holmes, cephalopods have some nasty habits. Ink sacks, sepia ink. Submarine apparatus - siphuncle tube pumps fluid in or out of chambers. 1st cephalopods straight Cambrian.

Nautiloids, in Ord., coiled. Devonian, new type of ceph., with crenulated partitions - ammonoids, which are dominant invertebrates in Triassic & Jurassic. Comanchean, they get loosely coiled, nearly straight. This suggests they were faced with extinction, trying to avoid it. By end of Cretaceous, they are gone.

12. Arthr. include crustaceans, insects, spiders, scorpions.

Eurypterids, extinct ancestor of scorpions, with strong mandibles

Spiders, Pennsylvanian to present.

c. Jurassic, modern crust. appear - lobster-like. Jurassic spider crabs. From J. to now, crustaceans have flourished without changing.

d. Insects. Most highly specialized invertebrates there are. Cockroach the oldest - Pa. pd. Dragon flies next. Larval stage of dragon fly found in Pa. E trilobites had larvae, which resemble Pa. dragon fly larva. Paleozoic - no butterflies, ants, bees, moths, etc. Tertiary, modern assemblage. Ants in amber, Miocene. Drone, worker, queen division made, has been maintained 8,000,000 years. They have not changed - no progress. "One for all", the motto. No individual regard.

f. Fish. Head class. of invertebrates, lab. manual & text. The record. Devonian - head, pharynx in bony armor plate, eyes, naked tail, 2 flippers. - Ostrachodermis. Also, fish with no fins, rather eel like, tail fin. Ordovician, plates of ostrachodermis found (!!)

Raymond, May 13

Unofficial outline. 12, arthropods.

Trilobites

Principal characteristics

Cephalon, thorax, pygidium, glabella, facial sutures, cranidium, free cheeks

Kinds of eyes - bunch of single eyes.

Size, geological range

Ventral side

Hypostoma, antennules, biramous limbs, endopodites, exopodites

Anatomy & food

Methods of locomotion

Reasons for extinction - stomach too big, brain too small.

Arthropods. Invertebrates, with segmented body & appendages. Skeleton of organic matter, hyaline???, flexible & strong, resists acids. In existence since E, trilobites, which lasted till Devonian, extinct by Permian. They are crustaceans.

2 longitudinal furrows, making it trilobate both ways. Vary in size, number of segments & relative size. No. of segments - 2-44. All arth. molt. Head has 2 eyes, sometimes 5. Compound eye.

Also have arachnid, conglomerate eyes. Crack around eye to keep it from being injured in moulting. Whole trilobites rarely found.

Glabella - $\frac{1}{3}$ of cephalon. Appendages Composite ^{aggregate} eye.

Some had stalked eyes. Segments go all the way underneath with legs. Antenna on some. Jaws extend whole length of body.

Fishes ate up all trilobites food, & maybe trilobites, finished them off. Location of stomach perhaps caused extinction, started to eat plants, stomachs got larger, brains smaller.

Arachnids - scorpions, horseshoe crab, king crab. Pi for hum. crust by having forward pair of claws, instead of feelers. Horseshoes in Silurian, Camb., now almost extinct.

E + mu
Devonian

Fishes

Finished them off.

Mathur, Fri, May 8

(Monday, Raymond on outthropods)

VIII A

- 7. Echinoderms - Crinoids, stem segments & calyx.
- 8. Vermes - segmented annelids only fossils.
- 9. Bryozoa - moss like
- 10. The conservative brachiopods. - lampshells live, others died.
- 11. Mollusca
 - a) The plodding pelecypods
 - b) Gastropods of sea & land
 - c) Cephalopods
 - Successful nautiloids

Rise & fall of ammonoids

7. Cystoids, ancestral type. Crinoids, sea lilies, a modern type - also living in Miss. - animal lived in calyx on top of long stem. Segments of stem found in limestone. Calyx, camera like, because it is box like. Surrounded by arms, which may be spread or contracted. Long things go all the way thru stem, to control it. Digestion like that of corked up worm, a sessile animal. Arrangement of plates in calyx makes species. Excretion, longest lived cystoid had unsanitary arrangements.

Blastoids, "fossil acorns". Now extinct, Paleozoic only.

Starfish, ~~more numerous than~~ Paleozoic, always a minority. Mesozoic, very abundant, as now.

Sea Urchins & Sea Cucumbers, prothothereans, back to beginning of Mesozoic. Result of settling down in life, limiting movement, Maginot line stuff; progress stopped - little development in them since they appeared.

8. Many phylum, but only 1 of them, the segmented annelid worms, are found as fossils. Once 10-12 feet long, no ornament, but jaws, ? citanans? material. But it is possible that all worms are descended from old segmented worms.

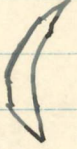
9. Bryozoans, 40 years ago called coral. But they have mouths & anus, coiled digestive tract. Pin point size. Nearest relatives are

10. Brachiopods, bivalved. But these also have respiratory organs. Begin in E. Many in which 2 valves not united by hinge, called

inarticulate brachiopods. But also articulate & forms

Shells strengthened by ribbing, corrugation. (Plicated shells)

To prevent twisting, hinge line lengthened. Some Ord. ones have short hinge line, instead have interlocking saw teeth, & sinus. Solid arrangement.

Some have 2 valves  so, thus making morsel less juicy. Such things lived not long.

One platform of loop bearing brachiopods. Also spiral bearing brachiopod. Criterion - always bilaterally symmetrical, but valves are unsymmetrical.

Devonian, spire-bearers are large & numerous. 1st genus of things to appear having everything - spira.  Fastest speaker now extinct.

Lampshells still living. others have perished.

Conservative brachiopods have persisted,

11.

Pelecypods - Clams & oysters. Valves symmetrical. Had to have hinges, crenelated forward margin. Only 1 pair of muscles, which both open & close shells.

Ord. clams

Generally, ~~trick~~ few pelecypods in paleozoic. After App, brachiopods down, pelecypods up.

VIII Fresh of animal life.

A. Invertebrates

1. Pre-Є records } every invertebrate phylum rep.
2. Є assemblage }
3. Protozoan progress - in cells, & in combining.
- 4. Sponges - gastrula form, developed by Є & Dev.
- 5. Corals & their diversification - upper end may be closed.
6. The short-lived graptolites - Ordovician
7. Echinoderms - fully developed by Ord., Cystids.
8. Verms

Polys. like
Raymond

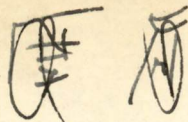
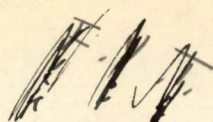
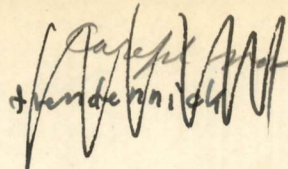
Greenlie limestone, cozoan Comadenis, mostly inorganic, some algae. 2 places where pre-Є rocks are not met. V Belt Mts. of Montana, much algae, Beltina danacae sort of pattern, crustaceans. A mistake. These are seaweeds, more algae. Also wormlike & bivalve animals.

2. Many Є fossils. By end of it, every phylum of invertebrates is there. No transitional. But only more primitive classes & orders are here. Period of 50,000,000 years, pretty rapid evolution.

3. Protozoa. Piling up of cells to make highly developed animals. But cells themselves progressed. Cells have structures. Also tests, houses around cell walls.

4. Let a protozoan divide, but remain in contact. When there are 16, they must be a hollow sphere in order to remain in contact with water. But too delicate to stay that way, go & pushed in, inner cells get specialized, body cavity formed. Modern sponge in this stage of development. Є sponges had rectums, fibrous skeleton. Budding. Constructed skeletons of silica, glass sponges, in Devonian. Both persist today. Bathroom sponges are elastic, fibrous, skeleton.

5. Coelenterata, differ from sponges in that upper end, where orifice is, may be closed. It is both mouth & ass hole. Tentacles close over to help close it. Secrets lime, outer wall. Septa. Є time, all corals individualists, have corals.



Chain coral the first known colony. Silurian, reef-building corals, Niagara Falls. Gorge. No interdependence or cooperation, all individuals. Silurian to present, many reef builders.

6. Graptolites. Ordovician shale. Look like hieroglyphs. Free floating colonies. Found everywhere, alike. A wonderful key to correlations. Lower Devonian they expire - started in upper O. No living descendants.



7. Starfish, echinodermata, spiny skinned. Pentameres symmetry. ~~As~~ Bilateral symmetry. Under side, at center, a large opening, mouth & ~~as~~ rectum. Ordovician, ancestral type.

Marker May 4

SEE Rogers

VII

c. The First Forests

1. Devonian trees

2. Coal forming plants of late Paleozoic

d. Advent of flowering plants

1. Comanchean (early Cretaceous) flora of the Coastal Plain series.

2. Grasses & cereals of the later Cretaceous

E. Plants during Cenozoic rev.

1) Segregation into climatic zones.

2) Effects of Pleistocene glaciation.

VIII

Hist. of animal Wd.

1. Naples, N.Y., in Catskills, oldest tree. Curved branches. Leaves more scales. Pteridophyte.

2. Pennsylvanian coal measures, many fossils of plants. Big tree-ferns, Calamites, ancestral to equisetum. Hollow, bamboo-like stalk. Short, stubby branches. Fruit at top, giving name horsetail to modern plant.

2 kinds, Lepidodendron & Sidularia, forest trees. Trunks filled with pithy, spongy crop, ~~not wood~~ No bark. Evergreens, like ferns. Grandpines descended. Fern-like leaves, species under them.

Also, some nondescript leaves - fern or other type of pteridophyte. Cycadophilopodes ^{cycles??} (Ferns are philopodes) Cycads bear seeds, are fern-like. In late Paleozoic, lived many of these transitional forms, now extinct. Naked seeds. Ginkgo. No flowering plants (Angiosperms) in Paleozoic. Animals thoroughly limited.

Permo-Carb. glaciation, denuded.

Triassic, delicate ferns.

P. Comanchean, deciduous angiosperm trees.

Arrived very suddenly, no transitional forms known. Why? Location basal beds of coastal plain series. Where would Jurassic rocks be? There are none in E.W. Am. W. N. Am. Jurassic are all marine

Lee Rogers

or desert. It was in E.N. Am. that angiosperms evolved, were not preserved as fossils till Cenozoic. No grasses, cereals, until late Cretaceous. Then all modern plants existed. Middle & Upper Cretaceous is dawn of time for plants. No great change since.

Cenozoic revolution, segregation into climatic zones. Palms, cypresses, oaks, & pines found growing together. Segregation only since Oligocene. Change of climate responsible. Also possible that they weren't such choosy plants, probably not.

Pleistocene refrigeration. Migration, adjustment, death the alternatives. Periglacial region (Fenn 100 miles), no plants adjusted. Extinction or migration. In west, above timberline, lush alpine meadows, grass & flowers. Alpine flora, characteristic of all high places. Surrounded by dark spruce forests, no Alpine flora, many "islands". These are periglacial plants, as Wisc. ice retreated, Alpine flora went up mts., just above timberline.

A number of islands of refuge. Driftless area Wisc; N. Scotland, Gaspé, Kenenaw uplands; endemic species, haven't migrated out of those places since.

Repopulating of ice-free areas. Migration in 30,000 years for 100's of miles. Some plants can still migrate farther. Tundra of our north will be invaded. Read
Ed Snider - 2/4-15

Mather, May 1

VII Hist of the Plant kd.

A. Classification of plants

- 1) Thallophytes
- 2) Bryophytes
- 3) Pteridophytes
- 4) Spermatophytes

Class gymnosperms
" Angiosperms

B. Dawn of plant life

- 1) Pre & Algae
- 2) & Plants (land)

C. The 1st forests

- 1) Devonian trees
- 2) Coal forming plants of late Paleocene

~~Plant~~ ^{Life} not discontinuous, like rocks. Classification is unnatural, it's forced on us by limits of human mind. There are $\frac{1}{2}$ plants $\frac{1}{2}$ animals, all other division lines are straddled by something. Relationship a good basis for classification. Not superficialities of structure, nor similar habits, but relationships, as revealed by??

Kingdoms. Phyla or branches. Class. Order. Family. Genus. Species. Individuals in a species can interbreed, many exceptions to rule. Binomial system - Homo Sapiens. Family - Hominidae, man the only living representative, there are many extinct genera & species. SubOrder (there are sub orders, sub families, sub genera) Anthropoidea (Chimpanzees, Gibbons, Orang-utans) Order - Primates. Class - Mammalia. (all warm blooded animals that suckle young) Sub phylum - Craniata (vertebrates) Phylum - Chordates. — Sub-species (varieties) None in Homo sapiens, too much interbreeding. i.e. we call its 4 subdivisions "races".

Plant kingdom. 4 phyla. (p. 214, Snider) Thallophyta - (phyta means plant) (Thallos means no differentiation of parts into organs) Single cells, or groups of independent cells. Algae, seaweeds

Take a course in Conservation.

stagnant water, much seaweed, brownish ropey seaweed. All live in water or moist places. Fungi in it - mushrooms, mold (any but of a mushroom can live) There are ^{no} intermediates twist thallo & bry.

Bryophyta - Mosses & liverworts. Some differentiation of parts, but no woody tissue. Reproduce by spores, this the most important difference of things, only spores can carry on. (Must live in water) Pteridophyta - winged plants, can fly. - the spore can. Ferns most common. Spores under hand fly. Differentiated - roots, stem, head. Rushes, scum-ing rush (which has silica in stem, which scours) (horsetail rush - N.W. cracks? Has tassel sometimes) Ground pine - has spores, grows 40-50 feet long. Has needles. Pter. have woody tissues, more complexity.

Spermatophytes - seed bearing plants. (Intermediate forms, now extinct) Gymnosperms - no pod, fruit, nut, naked seeds. Conifers, e.g., Cycads, Sequoia, Cypress, Sable Palm, Ginkgo or maidenhair tree. Angiosperms, seed coat.

Pictures: 1) Oldest known fossil not oldest stuff. It is thin section of pebble in congl., a pebble of Chert in Huronian age. Pebble itself probably pre-Algonian. Algae preserved in it, colloidal silica did it. 2) Stromatolites secreted by Algae. Lake balls, formed by Algae, in limestone. Eozoan Canadian, many balls named, which really were inorganic, but balls are genuine. In E, 1st bryophytes. (spore, tread sphere) Devonian - Naples, (N.Y.) Tree, 1st tree.

Mather - April 29

VI (2c) available working hypotheses (to explain glacial climates)
i Variations in terrestrial conditions

Composition of atmosphere

Circulation "

" " ocean

ii Variations in extra-terrestrial conditions

Energy output of sun

Cosmic clouds

VII History of the Plant Kingdom.

Conn. valley trip off.

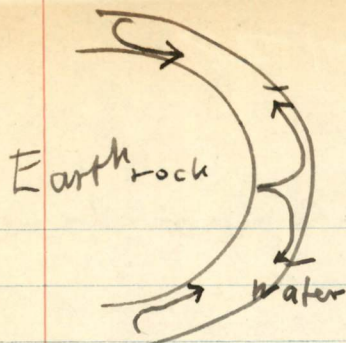
Comp.

~~Lowering~~ ^{Lowering} surface temp. of water means CO_2 goes to air, making it colder, more CO_2 , colder, etc. ad ---? How stopped? Stops itself. Spreading of ice sheets mean much rock is insulated from atmosphere, cutting down one process of ~~lowering~~ putting CO_2 in air. Also, life is depleted, balance upset, so pendulum starts to swing back. More CO_2 , ~~warmer~~ ^{colder}, so oceans liberate CO_2 , ice melts. But — this uncovers rocks, weathering stimulated, this takes CO_2 from air, changes swing again. These can explain fluctuations in one period, not periods themselves.

Dust in atmosphere, from combustion, vulcanism. Volcanic dust in upper atmosphere is envelope, chills earth, might explain ice. Krakatoa, e.g. Unlikely. Glacial drift contains no unusual amount of volcanic dust, altho some warm-weather rock does.

Circulation Mt. barriers, & land & sea difference affects. Aridizing means no ice. Ice got further in Wash. than in Mont., anyway. More examples. Precession & localization never explained.

Circulation of ocean - Humboldt current, Gulf stream, etc. Controlled by land barriers, water would otherwise go in belts. Japan current.



95% of ocean water has 36°F . temp.

Equalizing ~~balancing~~ system of earth, lowers whole temp. of equator, raises temp. of poles. - Or would, if it could be accomplished. Connection of water is not thermal - a matter of density, & salt content also determines this. Amazon R. water floats on top of Atlantic, because warmer & less saline. Medit. water flows into Atlantic, & sinks. Rapid evaporation in equator would make hot water sink, due to salinity differences, reversing circulation of ocean. ~~How?~~ In Tertiary, no Isthmus of Panama, no Gulf Stream, waters flow westward, are evaporated. Isthmus built at beginning of Pliocene, took this period for effects to accumulate & cause glacial climates. (However, water from gulf stream supplied H_2O for ice, - Gaffney's idea)

ii. Variations in extra-terrestrial conditions.

Sun is a variable star. $11\frac{1}{2}$ year sun-spot cycle. 400 year cycle. But ice ages are correlated with mt. making, & variations in sun would not be. But presence of mt. barrier allows small variations in temp. such as would be produced by sun cycles to affect ice ages.

Space between stars not so empty. Clouds of cosmic dust. These may intervene & twist us & bunch of stars - holes in milky way are from cosmic dust black out. Solar system may run into some cosmic dust. No evidence that we have, however. Mathur thinks varying of sun does it.

(O_2 in air warms up.)

VI C Theories of Climate

Mather - April 28

1. Available Facts

- a) Existing climatic conditions
- b) Climate of the past

2) Problems of glacial climates

- a) Conditions to be explained
- b) Unsatisfactory suggestions
- c) Available working hypotheses

i) Variations in terrestrial conditions,
composition of atmosphere — CO_2 means heat
circulation " " "

" " ocean

ii) Variations in extra-terrestrial conditions

b) Glacial climates, such as present, are abnormal. Old climates were more uniform. Triassic, plants growing in Antarctica.

2. a) 1) Worldwide refrigeration. Wisconsin nearly contempor. with Verrill ice sheets, also Patagonian, & all. 2) Several stages, of ice advance & retreat, in Pleistocene. Same in Permo. Carb. 3) Centuries of ice not poles, ice localized.

b) 1) Earth grown cold ~~of~~ idea. But external, not internal, forces, ^{one} major determinant of heat. And there were glacial stages before.

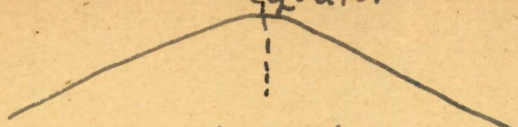
2) Elliptical orbit of earth makes it be farther from sun at perihelion, nearest at ~~perihelion~~ ^{perihelion}. But this has trivial effect. January ^{perihelion} July, ^{perihelion} ~~perihelion~~. Bias of axis causes seasons. Suggestion — once orbit more elliptical, & north was in shadow at aphelion. But this means alternating n. & s. ice, not so. Also, orbit could not be elliptical recently.

3) Continental drift. Wegener applied it to Permo-Carb.

Put continents together, put s. pole in Ind. ocean, & get all Permo-Carb. ice within 30° of pole, going right way. But overlooked Squantum, Permo-Carb. in Mass., which would be in equator.

Or apply it to Pleist., put N. Pole in Hudson's Bay, & all ice within 30° . Find if equator was where it should then be. San Francisco mts. of Ariz, Alpine glaciers at that time, 12,000 ft. Andes, snowcapped

peaks, with cirques below them, lowest at 13000 ft. Right on equator, lowest Wisc. ice cirques are 14000 ft., then ~~off~~ alt. of cirques goes down. Level of cirques: ^{Wisc.} equator



So equators were where they are.

C. Varying terrestrial conditions.

i) Varying atmosphere.

Atmosphere necessary to life. Moderates temperature. Neither Nitrogen nor Oxygen act this way, much. 2 gases, CO_2 & H_2O vapor, both of which fluctuate greatly, are thermal agents. High humidity, little fluctuation in temp. CO_2 present where there's much animal life, where volcanoes belch, where factories burn coal. (Animals abundant only where plants are) More important than life are ocean waters, cold water holds more than hot. Warm ocean a little bit, get CO_2 started out, warm more, same place is hot. Or cool ocean, cool more, get ice age going. Suggestion - Ice ages came after revolutions,

Mather April 24.

VI B 2 d

Isostatic adjustments

Explain vertical movement only

3. Summary & conclusions.

C. Theories of climate

1. Available facts

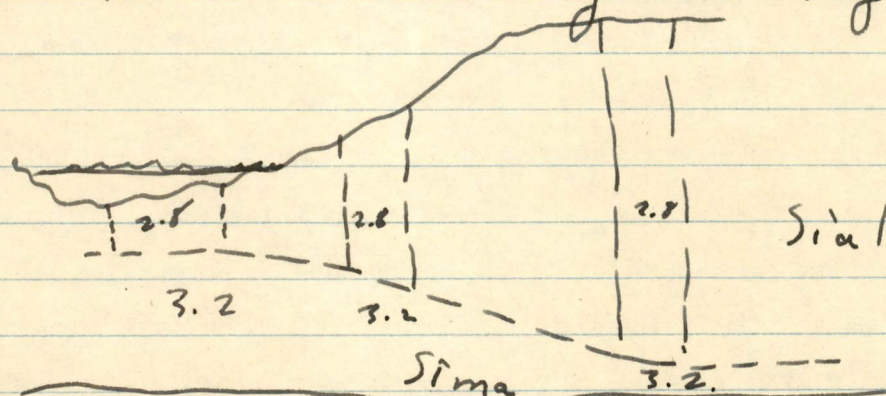
a. Existing climate conditions

b. Climates of the past

2. Problems of glacial climate

a. Conditions to be explained.

Fact of isostatic adjustment. But it may be that it is the effect of materials further down that makes the difference in gravity rather than surface weights difference in. This latter idea is more commonly held today.



These columns shift in large units.

If erosion changes weights, mt. column will rise, sea column will sink. This explains vertical movements.

3. Appalachians, for summary & conclusion.

Begin with App. trough. (We don't know how it got there) Beneath it, narrow shelf of immense material. Deposition of 10-11 miles of sediments, all in shallow water. i.e., trough must have sunk, ~~over~~, to keep it a trough. Then comes App. mts., involving horizontal compression. Compression will be relieved in weakest place, i.e., sedimentary rocks of trough.

App. trough becomes mts. 2 things may occur - 1) compaction of rock, it becomes denser. 2) Pushing of some of quasi-plastic substratum over to other places. Then it erodes away & when it does it gets lighter & is pushed up, rejuvenated. 3 parts to cycle. 1) Dep. 2) Hn. compression 3) Erosion & rejuvenation. Ganges - Brahmaputra trough in 1st stage. Himalayas in 2nd.

Cause of horizontal compression. Just 2 fertile ideas. 1) Earth shrinkage. Chemical reorganization the only possible way, involving acceptance of planetesimal theory. 2) Movement of quasi-plastic substratum. Convection currents, very slow. Explains both rift valleys, block faulting, & crumpled mts.

C. Theories of climate

1. Available facts.

Composition, movements of atmosphere, & solar energy. 3 factors of weather.

Not so homogeneous. Cold polar air is distinct from tropical air. Masses are so large they don't mix. Where they meet they mix slightly - turbulence, belts of storms. Also differ in humidity. (2 kinds. Relative humidity - % of total capacity of air to hold vapor at that temp. & % of vapor in air. Abs. humidity, obvious.) Cold, moist air mingling with warm moist air will reduce carrying power of warm air, increase rel. humidity, cause precipitation.

Movement - 2 causes. 1) convection, where 2 bodies meet & also within masses. From various insulation, or unequal reflection from ground. 2) Rotation of earth & moon's pull.

3 great belts around earth. 1, tropical, 30° to 30° , solar insolation at max. Trade winds, toward west.

30° - 45° Prevailing westerlies. (Easterlies rising on Andes precipitate, into Amazon valleys. Deserts to west of Andes)

Mather, April 22

VI B 2

Available working hypotheses regarding mt making

b) Changes in temperature

2) Movement of molten magma

3) " " quasi-plastic rock

c) based on external relations

1) Change of shape of earth

2) Migration of continents

3) Continental sliding

d) Isostatic adjustments

Explain vertical movements only.

b) Changes of temp. within earth, apart from loss of heat. Ocean boiling theory not supported by fossil evidence. Outer surface of earth not strong enough to transmit forces as suggested, anyway.

2) If there were a body of molten magma near surface (there ain't) it would have convection currents. (heat coming from below) Friction will develop between moving magma & crust above, will perhaps drag the crust laterally, explaining horizontal movements. Mather doesn't think so.

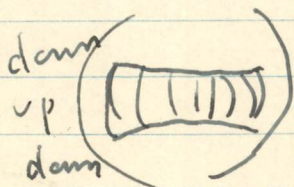
3) Alternative, with one important difference. Consider rigid rock down 25 miles. Down 50-100 miles, rocks may be weak, quasi-plastic, like wax. (Prof. Bridgeman, high pressure high temp. laboratory) Behave almost like liquids. Respond to hammer blow as tho they were solid, to long continued pressure as though liquid. (For, in many months, will lose shape) Convection currents will develop in sub-stratum, there will be a connection twist liquid & solid, over large areas, possible explanation.

c) Possible explanations based on external conditions.

1) Shape of earth determined by its rate of rotation, stresses put on surface. Earth is slowing down, 1 second in 400

years, due to moon, & tidal relations. But this would cause mts at poles, rifts at equator, not so.

Look at shorelines - submergence from Boston & Puget north. Emergence south, to Valparaiso. Similarly in Eurasia & Africa. Indies exceptional. Santiago ~~west~~ south, submergence.



Slowing of earth means more rapid movement of hydrosphere than lithosphere to poles. (Don't forget effects of ice sheet)

2) Mts. result of continent migration. Based on Pacific-moon theory. Wegener theory. Taylor had same idea, similarity between shape of mountains & shape of Atlantic mts. - push Americas west, push up mts.

Wegener fit all continents together, said they were the Sial left after moon pulled out, were cracked up, then, due to earth rotation & tidal forces they drifted west & equatorward. Showed that Greenland had drifted 80 feet in 40 years, but this was probly due to error in clocks, that old Danes had used. Recent observations show no drift. Also, ocean does not give enough resistance to build mts. If it did, continents could not move.

3) Hypothesis of continental sliding. expand under crust, loosen connections, let it slide. Tilting of continent, followed by sliding, pushes up mts.

Mather, April 17

Mt. club trip

VI B Theories of mte making (orogeny)

1. Available facts

- a) Geographic distribution of mte ranges
- b) Nature of orotetl movements.
- c) Periodicity of movements.
- d) Recurrence of "
- e) Relation between density & altitude

2. Available working hypotheses

a) Earth shrinkage

Loss of heat? Not adequate.

All day field trip to Conn. valley. Give him memo saying I won't go.

1. a) Distribution systematic. i) In long, curved, lines. Sigmoidal. ii) near borders, not in center, of continents. general rule. Urals, App., exceptions.

b) Horizontal compression

ii) Vertical uplift.

Appalachians - structure from horizontal compression, but height from just uplift.

App. rev. & Cenozoic rev.

iii) Occasional horizontal extension. Great basin mts., tilted blocks, E. African mts. Red Sea in rift valleys, as is Galilee.

c) Movements are periodic.

d) Recurrence

e) Isostasy.

2. Working hyp. is theory that is under observation, to see how well it works.

a) By balloon shrinkage, it has been proved that shrinkage will produce sigmoidal mts.

Heats being always conducted from center to crust to space. In 100 000 000 years, earth

will be $10-45^\circ$ cent. lower. This would shorten radius of earth $\frac{1}{4}$ -1 mile, & shrink circumference 6 miles, ($2\pi r$). But 75-100 miles of shrinkage are necessary.

But it may be shrinkage not caused by loss of heat. If planetesimals formed earth, radius has been shortened 1000 miles. (because of increase of earth's density to 5.5, over 3.5 of planetesimals) But this cannot explain present mts, only very old ones.

Chemical reorganization of earth's interior, tending to form denser material, will explain 75 miles of circumference shrinking since Cambrian.

b) Changes of temp. within earth without loss of heat.

Heat might be locally concentrated - radioactivity. Whole lithosphere is radio active. Ocean basins more radio active than Sial. Expand ocean basins, pinch continents - very good. But mechanics of earth crust may forbid.

4 Tidal theory (cont.)

a) Statement (cont.)

Satellites formed

Orbits made circular by resistance medium

b) Comparison with planetesimal theory

c) Advantages

d) Objections

5. Current Trends of thought

Satellites formed by pulling stuff from sun, when orbits are highly elliptical. At perihelion, great tides formed on planet. Tidal resonance - bulge of high tide toward sun. Resonance developed between rotation & vibration period of earth, till earth pear-shaped, with rotation still going on within the pear. Finally end pinched off.

Pacific ocean basin is where moon came from. Atlantic basin is from continents moving over trying to fill up Pacific.

Objection - earth must have become nearly solid right after thing left.

Orbits — very eccentric right after star left. J & J say that, due to expansion of gas, there is a resisting medium. The gas that escaped & formed planets by adiabatic cooling, is still within control of sun, is resisting medium, & makes orbits circular - the larger the planet, the more it would be affected, & so this fits the facts.

b) Comparison.

i) Tidal theory takes just a few thousand, 5-50, to create system. Planetesimal theory takes millions.

ii) Tidal Theory has earth molten when full grown.

Plan. " " " built up by accretion of solid fragments

If molten, metallic core & rocky shells, with sharply defined shells. If pl. is right, planes of demarcation will be transitional, not sharp. But no one knows. But even if planes of wave deflection are sharp, this may be because skeletons ~~planes~~ of rock & skeletons of metal are sharply defined, but not the actual ~~~

iii) Pl. - man & earth are twins

Tidal - man is earth's offspring.

Advantages of tidal -

I It explains earth's stratiform interior

II " " segmentation of outer shell of earth.

d) Objections

Satellites could not have been formed as J & J say. Many moons are not in plane of orbits, as they should. But this can be explained - capture of some other moons might have upset things.

Also, resisting medium must come back to sun, & contact of planets with medium is only slight modification of Oh. theory.

Geologic objections. theory of earth origin should explain mt. making. Shrinkage of earth possible explanation, but Tidal theory does not allow for this, as Pl. does. Mather's chief objection.

5. Current trends of thought.

Astronomers have worked selves into impossible situation. They proved impossibility of creating earth, on basis of their principles of celestial mechanics. Oldest meteorites are c. 2 billion years old. Oldest rocks on earth age a little less. Latest theory is that universe blow up, producing stellar galaxy & solar system, is expanding.

Compromise theory - Dynamic encounter. Perhaps our sun was double star. How earth $\frac{3}{4}$ liquid. ^{present size,} Then long delayed earth shrinkage on long scale.

Birth & Death of the Sun - Gamow.
" "
Biography of the Earth

VI 436 Objections to Planetesimal Theory

i) Astronomical

ii) Biological

4. The Tidal Theory (Jeans & Jeffreys)

a) Statement

Dynamic encounter causes ejection of Planet or gas
Planets condense from fragments of filament
Satellites formed
Orbits made circular.

b) Comparison with planetesimal theory

c) Advantages

d) Objections.

Philosophical — Laplacean Theory is cul-de-sac. Planetesimal suggests possibility of repeated cycles. (Meteorites contain minerals suggestive of planetary conditions (oxygen & water)) But here also is suggestion of cul-de-sac. Each time there is dynamic encounter speed of stars is lessened.

b. Objections, astronomical

astro-physics. relation between temperatures & molecular velocity. Sun's periphery's molecules are moving so fast that result of dynamic encounter would be diffusion of gas into outer space. Also, collisions between planetesimals (if there were any) would exceed accretions, vaporize & diffuse planetesimals. But against this is fact that planetesimals do exist (meteorites)

Geological objections

i) stratiform structure of earth's interior.

~~Planets~~ Lines of demarcation twist strata are very sharp, rather than transitory. A fully gassy, wholly liquid earth is necessary to explain this. Heavier liquids settle to center, being immiscible, like Billiomine, would be sharply discontinuous. (but we don't know yet)

if they are discontinuous or not

Other earth is segmented. Chond. explains by selective aggregation of planetesimal dust. But there is also the idea that ocean basins were once continents. Neither is definitely known.

Tidal Theory

Bartish Sir James Jeans, astro-physicist.

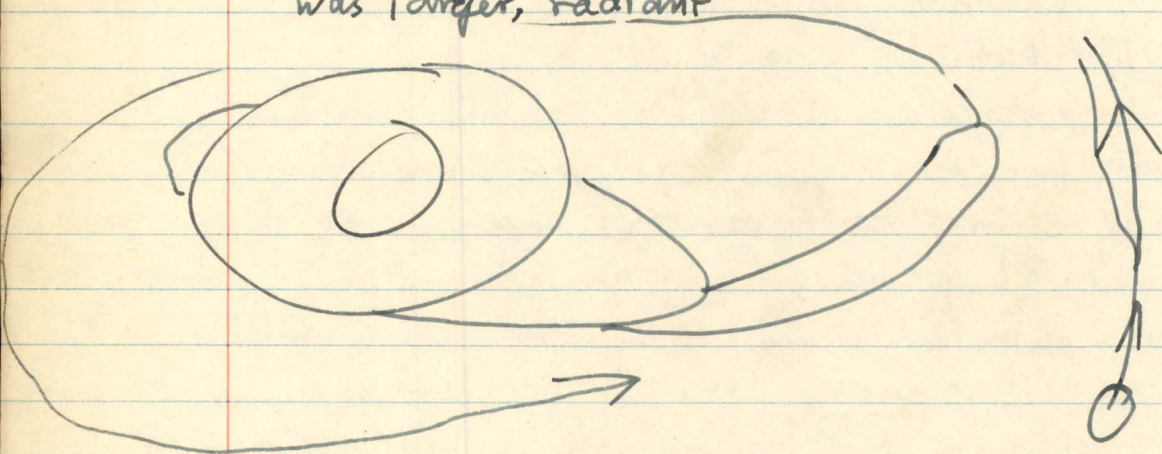
Harold Jeffries, geo-physicist.

Much personal bitterness - J. & J. made their theory look new, tho it is only modification of planetesimal.

Assumption - once, when sun was much expanded, there was dynamic encounter.

When star is diffuse, it radiates more energy. ^{& light.}

As it contracts, it becomes dim, red, & dense. 1 cubic inch weighs 10 tons. Sun is mature. 2 or 3 billion years ago, it was larger, radiant



Nearer side would be much nearer, there might even be mingling of exteriors, if disturbing star is very small. Tidal pull great, filament of gas pulled out. Filament will break - this is Achilles heel - no explanation of this. Break filament when in position as shown, each section becomes a molten planet.

But this does not work for minor planets. - they would not have enough gravity to hold together. Jeans explained by

adiabatic cooling. - principle of mech. refig. Gas compressed, as it expands it cools. As part of gas dissipates, it cools remaining gas to a liquid. Would take 5,000 years for earth to condense. (Pl. took billion years)

Orbits at first were most elliptical. As each planet was at perihelion, it might drag out another filament, make satellites.

Moon - dragged from earth by solar tide at perihelion. Tidal resonance - pushing swing principle. Being in resonance with coffee cup makes it spill.

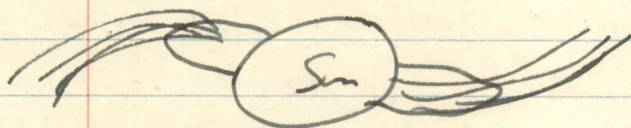
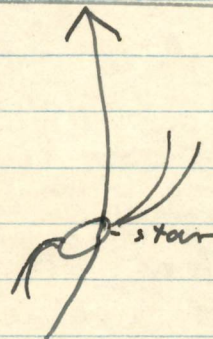
Mather April 10

Kant he actually suggested something like nebular hyp. in his writings.

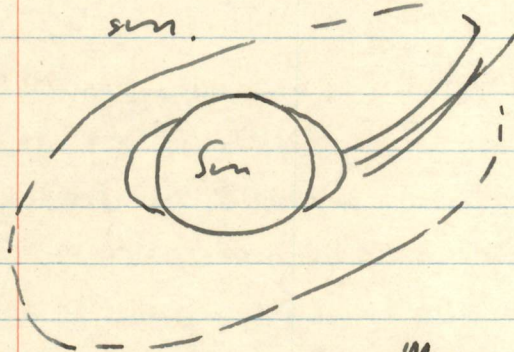
VI A 3 a

- ii. The Planetesimal ~~theory~~ nebula
 - iii. Evolution of nebula into solar system
 - iv. Juvenile history of the earth
 - v. philosophic effects of planetesimal theory
- b. Objections

ii



Tidal forces (like forces that produce tides) pull out sun. lessened gravitational influence of sun, explosions shot out further, did not fall immediately back into sun.



moment in elliptical orbits, this started.

$\frac{1}{7}$ of 1% = planet's mass to sun's.

Many small particles ^(or planetesimals) thus whirling around sun. ~~Planetesimals~~ Hence planetesimal theory. Nebula thus does not have to be assumed - it follows from dynamic encounter.

(iii)

Matter began to gob together. Orbits being so eccentric, many collisions, which may result in accretion. As a result, change in orbits, new ones being more circular than both the old. Therefore, largest planets should have most circular orbits, as they do. Passing star determines plane of orbits, oblique blows in accretions cause slight deviations.

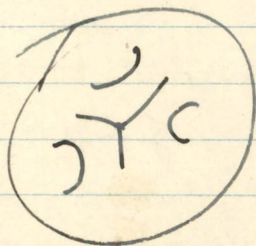
Forward rotation, why? (George Darwin's thought)

constructing system from swarms of meteorites. But this objectionable, because: inner meteorites move faster, if meteorites collected, inner ones would go faster, rotation would be retrograde. But for some reason, math. chances are that most accretion will be by faster ones from outside, slower ones from inside, explaining forward rotation. As for moons, planetesimals can be captured. Chances are again for forward rotation. But our moon is too big, this is impossible. So must assume that earth & moon were together ever since first explosion. Probly at first ^{earth} was but 8 times larger, now 81 times larger. - grew faster. 60-70% of earth has been added by accretion.

Elasticity bad for accretion. Metallics less elastic than silicates. ∴ metals were gathered in first, silicates later.

(Mars 10 mass of earth - CO₂ only atmosphere - very slow, heavy, gas, only one it can hold. Moon no atmosphere, too small to hold any. Atmosphere grew as earth grew. Finally, it was able to hold even water vapor - beginning of hydrosphere. Sometime after, earth fit for life. Life could have been here when earth was $\frac{2}{3}$ present size.

Silica will go into solution at lower temp. than metals, so first magmas will be silicate. - thus silicas get to surface.



There should be 3 cracks from each pole. There are. There are 3 shields radiating from each pole. Oceans between one cracks.

Also 3 great currents. ^{swinds} These would whirl light materials to sides for continents, heavier ones in middle, ocean basin. Sil. v. Philosophic aspects. Passing star rejuvenated deep pit sun. This suggests cycles without end, destruction of

present system by passing of new star, formation of new.

Mather - April 8

VI A2

Laplacian theory

a) Statement of theory.

b) Defects

i) Geological discrepancies

ii) Astronomical data

iii) Dynamic inadequacy

3. The Planetesimal theory

a) Statement of theory

1) Dynamic encounter of 2 stars

2) Planetesimal nebula

3) Evolution of nebula into solar system

Some comets, parabolic path, not in solar system. Others, ~~parabolic~~ ^{elliptical} in it.

a) 1796, Pierre Laplace, hint from Kant.

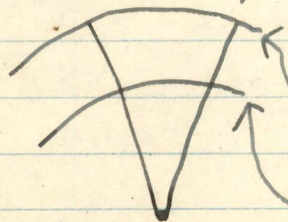
Assumed - once, in space, there was a huge body of hot gas rotating on axis. That's all.

He could not think of any reason why it should rotate, so he assumed it.

Space cold, gas hot, so it lost heat. This must
1) shrink gas, and 2) increase speed of rotation.

(by principle of angular momentum) (~~but~~ does ~~not~~ increase actual speed of particles.)

At 1 point, centrifugal = centripetal force. Thereafter, equatorial bulge cannot change size, and nebula inside shrinks, leaving ring. Then it shrinks reaches new equilibrium, breaks again, etc.



if this is 2 sides of ring which is being made into ball, this goes

faster than this, so rotation

will be forward.

Moons formed similarly.

Gas would then liquefy.

Then it cools, and plants & animals grow.
End of statement.

Rings of Saturn discovered before his death, considered proof.

b) George Darwin, math. astronomer, Charles' brother, showed some discrepancies, not listened to.

i) Geological discrepancies - earth, as ^{far as} we know, is not progressively cooling. But answer is, body heat of earth no longer determines climate.

ii) 2 new planets, Neptune & Uranus found, made earth ring number 7, folks thought it was lucky.

But now we know, outer satellites of Saturn & Uranus have retrograde revolution. But perhaps they are comets captured by the planets. But Phobos, inner of Mars' 2 moons, goes faster than Mars (It cannot be a comet, it could not have gotten in) Saturn's rings also go faster than Saturn, are made up of small chunks of meteorites. But this principle does apply to solar system as a whole - inner ones actually move faster - but sun ~~moves~~ rotates ^{too fast} ~~too fast~~ ^{of what it should.} What's more, plane of equator of sun is 5° off plane of planets.

iii) Dynamic inadequacy.

Modern knowledge of nature of gas. Kinetic theory of gas - it is composed of separate molecules. Put material of earth as gas into a ring, it will be too thin to stick together.

Planets have 97% motion, $\frac{1}{10}$ of mass in solar system, something not explained by Laplace.

1895-1910, T. C. Chamberlin, U. of Chicago, great guy, working on glacial moraines, got idea of repeated glaciation, asked why. Looked into astronomy, called in F. R. Moulton, mathematician of celestial mechanics (bro. head of Brookings). in 1904, planetesimal theory. Assumes - sun once came near another star.

Once every 3 or 4 billion years, this should happen. Not collision, but dynamic encounter. There are violent explosions on sun surface. Some stuff

That is all.

sun

star

Mather, April 6

VI Earth Problems - because we don't know.

A. Theories of earth origin

1. Facts to be explained
 - a. The solar system
 - b. The structure of the earth.
 2. The Laplacian theory
 - a. Statement of the theory
 - b. Defects in the theory
 - i. Geological discrepancies
 - ii. Astronomical data
 - iii. Dynamic inadequacy
-

A. Oldest rocks known are not part of original crust

1. a. Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto

1st 4 all relatively small & dense. $2\frac{1}{2}$ to $5\frac{1}{2}$ spec. gravity. Earth densest of all.

2nd 4 are larger & less dense. Saturn would float in water.

Pluto more like inner quartette than outer one. All planets move same ~~way~~ direction, and are in one plane, nearly. There's a relation between length of year & velocity. Earth, 18 miles per sec. Inner ones speedier, outer ones slower.

Orbit of earth is ellipse but major axis ⁶⁰ longer than short. Arrange planets in order of size, & they are also arranged in shape of orbits, larger ones less eccentric.

Each rotates upon axis. Earth rotates forwardly . So do all others (save maybe Uranus)

But rotation periods unaltered. Jp. 10 hours, Mars about 24. Venus indeterminate. Mercury takes

68 days to rotate, and also 68 days to revolve.

Many have moons. Mars, 2; Jup., 12; etc.
Our moon revolves forwardly around earth, as do most moons (not all). It rotates forwardly. 28 days is both rotation & revolution period, as in Mercury. That's why we never see other side. Moon bulges toward earth, & having this bulge cannot get away from this business. Tidal forces slow rotation all are tending to Mercury's fate.

61 to 1 is ratio of earth to moon.
Saturn's ~~Saturn's~~ moon Titan is bigger than ours.

Between Mars & Jupiter are asteroids (should be named planetoids) 306 of them, known. Orbits very eccentric. - one goes outside Jup. & inside Mars. Not as strictly confined in the plane.

Comets - very eccentric orbits. Very diffuse, rare, gas. Luminous, but without heat - electrical.

Meteorites - dense, 400 here. Light from heat from friction. There are certain crowds of meteorites around sun. Others may come from outer space.

b. Earth built stratiform, like onion. Outershell segmented. (SEAL, SEMA)

Creation stories all have Maker.
Laplace, end of 18th, impressed by Kant, & by systematic organization of sciences. Nebular hypothesis, accepted by his death in 1827.

Mather March 27

Vh 2

6. Proterozoic era

Timiskamian-Sudbury series

Algonian revolution

Belt series
in northern
Prockies

Bruce series

Cobalt series (includes tillite)

Animikean series of sedimentaries & volcanics

Keweenawan series of volcanics & sed. with intrusives

(copper & nickel)

Pillarney revolution

Cobalt

Algonian revolution a repetition of Laurentian. Non-laminated basal conglomerate. Larger stones in it are fer and fm. Matrix is groundup rock, rock flour. On surfaces of stones in it are ~~glacial~~ scratches. Glacial? Maybe. Probably. Cobalt conglomerate is a tillite. Central Ontario. Not, probably, as great a glaciation as pleistocene.

Huronian

Central Wisc., Baribau hills, perfect quartzite. Some inclined, others flat. Huronian quartzite. Iron ore - sandstones containing iron oxide; plants in bays & marshes cause precipitation of iron oxide. Or maybe iron rich magma flowed into the water. But since this deposition, more iron oxide has accumulated - no no. Groundwater has carried away silica, not iron oxide. Mesabi was 75% iron ~~ore~~ oxide. Ore shipped to coal fields. 75% steel industry dependent on this.

Late Proterozoic -

App. through Prockies - Ontario trough,

Animikean-Keweenawan, becomes more volcanic as we go up. Native copper. On Keweenaw peninsula. Traded to Fla, this copper. Agassiz family happened to own

land with this copper on it. Rensselaer Iowa flows
had much cu in them, prec. at.

Tertiary cu ores in Penn west now valuable.

Near Sudbury Ont, Rensselaer thick sill, exceptionally
basic, nickel sulfide ores. World's most important nickel
ore body.

Black hills, covered by these late Prot. seas, pre-E. rocks.
Gneisses & schists, and ? gneiss? . Deposit of gold bearing
substances, Homestake mines monopoly. Prof. McLaughlin,
former Harv. prof, was Homestake consulting engineer, their
stock rose from less than 100 to 1400, they split
them, now worth about 200.

Grand Canyon - proterozoic, not metamorphosed.

Belt series - , Montana. Sandstone & shale. Pre-Cambrian
here more easily eroded than other stuff. This
an exception to general rule. There is no
break between Camb & pre E. Algonian & Kill. revs.
did not strike here.

VH Pre Cambrian

1. The basement complex
2. Sequence of events

a) Archeozoic era - Dominion which is older
 Trematite - Catchiching volcanoes and sediments
 the oldest known rocks

→ Grenville series of sedimentary
 Laurentian revolution. Gneisses & schists

b) Proterozoic era

Timiskamian - Sudbury series

→ ~~Algonkian~~ Algonkian revolution - granite & gneiss

Bruce series

Cobalt series (includes trillite)

Huronian series with iron ores

→ Killarney gneisses. ~~schists~~

1. Valuable metals in pre-e. - digging them out gives hist. #
 very few fossils. "Muskog swamps?"

3 batholiths - 3 cycles? (have been 3 since)

Archeo Laurentian, Algonkian, Killarney
 gneiss & schist.

in 1870, marked end of Archeozoic

Protero -

Pitchers

pre-Camb. Indt. Canadian shield (Sc., n. Sib., India, other shields)

2. Long, discontinuous series of exposures along piedmont, Blue Mts., Smokies, & old borderland.

3. Very discontinuous series along Cordillera. - because it's along anticline.

4. Miss. valley, at apex of domes, Black Hills, St. Francis, Arbuckle, - Burnett dome,

Everywhere, if you go deep enough you find basement.

tundra, furze-bush

Keewatin, pillow lava; it is formed when molten lava
pours into water. Lava flow can't be original crust of
earth.

1,200,000,000 years old.

1,800,000,000 " " rocks in Australia.

Catchiching is sed., maybe older.

Grenville series - marble & crystalline limestone. 40,000-100,000 ft.
in thickness. Specks of graphite in it. " there was life in them
days. (not absolute proof)

Then Laurentian granite-gneiss is intruded into them,
"lit par lit", bed by bed injection.

End of Era

Timiskamian - ^{Sedimentary} series rest on batholith. Sand, mud, calcareous
oases. Huge delta built into Sedburg ocean.

Mar. 23

IG. 3.

- b. Volcanism & diastrophism in W.N. Am.
- c. Post-glacial change of level in E. " "
- d. Recent erosion & sedimentation

Along coasts

In interior

H. Pre-Cambrian time

- 1. The Basement Complex

b. Very recent. Perhaps when Indians were here. San Francisco earthquake, Cenozoic revolution. continuation. Many faults & lava flows. Also a general uplift. Hollywood, Pasadena, on old ocean floor.

c. Maine, etc., drowned valleys. (From Boston northward) But there is also a post-glacial uplift. But sea rose as ice melted, 200-300 feet. But that does not explain submergence, which is ~~different~~ ^{different}. But latest movements have been upward. Greatest movements upward have been where ice was thickest. This diastrophism cause of recent earthquakes. Change in temp. & expansion since glaciers may account for many cracks in rocks.

c. Nantasket — some drumlins, cliffed by waves, now separated from beach by long, low, flat plain. Nantasket beach is tombolo, made from drumlins.

Rivers post-glacial, in n.e. follow circuitous consequent courses. Cirques are being filled in.

Beginning of recent — when ice melted away from central Canada.

Natter Mar 20

Bring a Little to each table.
milk.

IG.3

- a) Glacial & interglacial stages of Pleistocene
Glaciers in western mts.
Lakes in great basin
Other continents
- b) Vulcanism & diastrophism, western N. Am.
- c) Post-glacial change of level in n.e. N. Am.
- d) Recent erosion & sedimentation
coastal
interior.

Sun., lasting all week.
Spring vacation course in surveying, Dr. Bryan. Valuable training

Glaciers in western mts. In mts., then went down to plains as piedmont glacier, went over and met Keweenaw. This around Canada - U.S. border. Also a piedmont glacier to west. So in mts., features of vigorous erosion, and deposition on plains. Farther south, in Oregon, ^{central} Rockies, Sierra Nevada, only mt. glaciers. Present glaciers may be new, growing ones, not remnants. Mt. lakes from morainal dams. - glacial erosion + glacial deposition. Interplay of stream & glacial erosion in glacial fluctuation periods. U shaped glacial valleys.
& rejuvenation.

Great Basin - Lake Bonneville, (Great Salt Lake remnant) Old shorelines show it - there are several different shore lines. At that time a fresh-water lake, flowing out to north. Various balances reached between rate of evaporation (humidity determines) and supply. Climate more humid then. Max. humidity contemp. with maximum icing.

Other continents - southernmost Eng. never glac. Center of sheet in basin, not mts. Backbone of Denmark a moraine, analogous to Long Island's. Gumbo mud of ~~Illinoian~~ drift in Eur., hard on wheeled vehicles.

Moscow - Ill. drift, like south, Ill.

Baltic states like Wisc., lakey.

England - Scotch Highland ice, & other mt. centers. Pre-Wisc.
(Ill. = Miss)

In App. rev., new trough, w. of Rockies. Trias. and Juras., sed. in it, then, end of Juras., folded and uplifted, Sierra Nev., intrusion of large bath.s, of granite, cores of present ranges. Hot water, mineral deposits. New trough to west, sediments from Sierras in it, uplifted in Cen.

Middle-Jurassic, first known subm. of Mex, etc. Limestone. Then, Comanchean, water spread n. to Tex. and La. Temporary emergence of Mex. ^{at end of} ~~dying~~ Com., then Com. and E submergence. Tampico oil in K lime. K seas, broad Dakotas, etc., belt, getting sediments from Rockies, (Colorado sea) none from east, so limestone there; slight elevation, coal swamps in west.

THE CENOZOIC REVOLUTION (ERA)

PALEOCENE (Laramide or Himalayan)

Great disturbance and mountain-making. All continents elevated. App.s, which were now flat, reelevated. West, Mes. troughs folded. (Rockies, Mex., and Andes.) Se coastal plain still thin, ne thick. Shifting western coastline.

Tertiary, west. mts. lowered by erosion. Green R. Lake, Col. & surroundings. Swamps and coal, plains. Eo, Mio, Olig, Columbia Plateau flows.

PLIOCENE AND PLEISTOCENE (2nd active phase--Alpine or Cascadian)

Moderate eastern uplift. Great western uplift. Overthrust faulting in folding of eroded Laramide ranges.--n. Rockies. Cascade and Coast Ranges up.

Mid-Miocene, Holarctic Continent broken. Restored in Pleistocene, destroyed in recent. Huge uplift in many parts of world. Pleist. Volcanic, Pleist., along west. mts.

Paleo, eo, general lowering of temp., after moderate, uniform Cretaceous. Oligocene, return to normalcy.

Miocene, renewed activity, erratic climate.

then wind-blown red clay on top, seas returned. Stassfurt mines. These seas gave organic black shale, decay of fish in which made copper.

Latest Permian, general elevation.

NORTH AMERICA FROM DEVONIAN ON

DEVONIAN

A) Restricted seas. Fluctuated in troughs

B) Onandagan flood from App. trough over most interior basin. Acadians uplifted, eroded to Catskill formation, much like its contemporary Old Red. This uplift lifted whole eastern trough and very slightly the west.

C) Central west dry, sw wet. ~~ne~~eastern interior basin, thick, coarse sediments at foot of mts. Black Sea in western NY, and betimes other places---Devonian Black Shales, thickest known.

MISSISSIPPIAN

(Maximum quiescence and submergence)

Deep Acadian valleys flooded, cut off, gypsum. St. Lawrence submerged. Continental Acadian deposits, not as red as before, climate was less arid. Interior basin deeply submerged. Pocono sandstones, thick, along eastern borderland. Eastern basin all submerged, western partly and intermittently. Then Chattanooga Shale, only small.

Close---uplift and withdrawal of all seas. Southern and western troughs began to fold. St. Francis dome formed. Great unconformity.

PENNSYLVANIAN

Subsidence again. Broad, shallow western sea, coal measures deposited in east---oscillating swamps and seas, coal and protecting deposits. General subsidence. Eastern Basin. Squantum tillite.

Squantum tillite, Permian-Carb.

4
PERMIAN

Elevation, mountain folding and uplift. Kansas, etc., gypsum.
App. revolution. Continental redbeds.

APPALACHIAN REVOLUTION. (Perm. climatic in Alps, Perm. in U.S.)

(Hercynian in Europe) V shaped system, Ireland to Carpathians.
Re-elevation of Acadians. App. trough folded to mts. Ozarks, etc.,
e. int. basin up, now again down, Europe ditto.
once connected with App. Uplift in west. trough, s. part. V-shaped,
apex in Texas. Intermittent glaciation in India. Permo-Carboniferous
→ ~~squatinid~~ Tillite near Boston. Greater rev. than Cal. or Cen. Climate upheaval?
Varied climate.

THE MESOZOIC ERA

Triassic and Jurassic, erosion and continental deposition. Red beds of
Conn. valley trap.
Comanchean and Cretaceous, like Ordovician and Mississippian,
great submergence and limestone. Holarctic continent, submergence
of eastern borderland, emergence of e. interior basin, subsidence
of Tethys trough, Gondwanaland.

~~Triassic~~ TRIASSIC transitory, Jurassic coal-measures, Comanchean
and K mild and uniform. T redbeds on At. Coast.--cont. and igneous.
(Conn. valley trap, Hudson palisades,) Correspond to old red, dep.
at base of Caledonian mts. T. Aeolian redbeds, SWUS - redbeds & rock salt.

JURASSIC

App. up, deposits in Atlantic, none now found in e.n.A.

COMANCHEAN

Cont. deposits, N.J. to south. Lakes. S. plain depressed, N.
plain up.

CRETACEOUS

Greenland tropical. / Then present topography (of e. N.A.) is re-
sult of glaciation and erosion in Cretaceous peneplane.

Permian, Triassic, and Jurassic, erosion of w. trough mts.,
continental redbeds, aridity. End of Triassic, and Jurassic end,
sea in from north. End of Jurassic, w. mts. lowered, clays laid,
and coal in Canada.

GEOLOGIC HISTORY

CHAP. 6 --- The early Paleozoic Cycle.

Ending pre-Cambrian time, the Killarney Revolution, and then the Lipalian "Era" of erosion.

Features---Central Interior lowland and Canadian Shield, eastern borderland (Appalachia); southern borderland, Mexico and Gulf; western borderland, west of Sierras; APP. trough, present mts.; central Texas, etc., southern trough; western trough, great basin etc.;

CAMBRIAN

(First encroachments of seas on present land areas)

A) Western trough flooded from both ends to the middle. App. trough flooded from Pac. thru Tehuantepec. Acadian trough flooded from Atlantic. *Petidar Sandstone, E.N.Am.*

B) Western interior basin flooded from trough. App. trough dried. Acadian trough same as before.

C) Whole west uplifted, dried. App. flooded, and eastern interior basin. Limestone deposited.

CLOSE---Green Mountain disturbance, said mts. formed. Seas completely out. Little folding.

ORDOVICIAN

(Longest period. Uniform, uneventful, gentle warpings) *West dry.*

A) (Canadian) Limestones, sands, few shales.

B) (Trenton) Most widespread limestone deposition ever.

Uplift to end this epoch, then submergence for

C) (Cincinnati) Clay shale

CLOSE---Taconic disturbance---maybe from Taconics to N.S.

SILURIAN

A) ~~XXXXXX~~ (Niagaran) Oneida-Medina formations of gravel and sand in N.E., limestone everywhere, almost as big as Trenton. Corals in Arctic, *E.N.Am.*

2
B) (Salinan) Alluvial cones in eastern interior. Under them, gypsum and salt. Muds and sands of cones oxidized to red. Aridity. (Mts.)

C) (Monroan) App. trough flooded from Pac., spread over ne, still arid, dried to dolomitic limestone, gypsum and salt. Then ^{trough} reflooded, normal conditions returned. West/flooded, too.

CHAPTER 8 THE CALEDONIAN REVOLUTION (late Silurian and most of Devonian)

Caledonian Mts. folded; Acadian mts. folded. ^{Bartholomew injected} Overthrust in both of these. Oklahoma and Kansas folded, soon bevelled. Vulcanism in Acadia, Caledonia, Ouachitas. Cold and glaciation in the north. Seas not affected. Holarctic continent formed. Acadia welded to Canadian shield. St. Lawrence Valley above water.

CHAPTER 8----LATE PALEOZOIC CYCLE - Europe

DEVONIAN

Erosion of Caledonians. Old Red Sandstone in Central Europe, aridity. Later Dev., flooded, low, swampy shores, coal and sand along shores.

MISSISSIPPIAN

"Culm" phases, coal alongshores, Mountain limes in center. Rise of borderlands in middle, shale and sand. End, Hercynian Mts. or Paleozoic Alps begun.

PENNSYLVANIAN

Folding and uplift of troughs. Limestone in Russia, in shallow seas. Swamps in western Europe---intermittently flooded, covered with marine deposits, and coal formed.

PERMIAN

Crustal movements, but seas persist in Russia. Salt Range of NW India. Germany land, Caledonians re-elevated, Hercynians standing.--these mts. shut out moisture, made arid, "New Red Sandstone" laid on top of coal measures, in England; Red Clay in Germany. Later Permian, sea invaded from Russia, ^{magnesian} limestones, as sea was later disconnected, with Mg and K salts deposited,

Mather - Feb. 4

IV B2 Geologic Time-table

Get Mon's notes. ± 25 million years error margin.

C. Before 1915. - knew, by physical relationships, which of 2 rocks was older. - relative age.

After '15, we know how much older

Time has no subdivisions, naturally. We make artificial ones.

Era - major unit

Period - divisions of era

Epoch - " " period.

Stage - " " epoch

Use mt. - making disturbances as divisions.
Bigger (areal) disturbance, bigger unit.

Era - worldwide disturbance

Period - continental

Epoch - non-mt. making, just shifting of sea.

Stage - maturity to old-age.

Cycles & eras.

Paleozoic - ancient life

Mezozoic - middle life

Cenozoic - recent life

Carboniferous - most rocks not coal.

Smith - "strata", tried to give lithological names to periods, but that doesn't work (arenaceous, calcareous)

So we give regional names - Devonshire, Devonian.

Cambrian - Cambria (Wales)

Type names mostly from western Europe.

both ^{ms}
syncline $\nearrow$
& v. anticline
top $\nearrow$

There's what I have -
Red Ged!

Question validity, recently. All eras of different length.

So there's a new time-table.

3 great revolutions, since Cambrian, with roughly the same time interval. Cycles.

Cycles

1. Ending with Scotch Highlands

2. " " App.

3. Mesozoic & Cenozoic make 3rd cycle.

We know about shallow seas.

Borderlands, basins, & troughs.

Paleogeography discovers.

Petroleum from rocks laid down near shore.

\$ from drawing paleogeographic maps.

Mather, Feb. 6

Paleogeography

V. History of the continents

A. Borderlands, basins, troughs

1. Paleogeography

4 spots in U.S. of upper Cambrian ^{sandstone} Marine sediments. Many hypotheses about ancient seas possible. More evidence. Spots disappear beneath younger beds in all directions. No conglomerate-sand-shale progression. Drill wells, get evidence. Sand-stone continuous from Wis. to Mo. 2 eastern ones continuous.

Life not unlimited in space. Panama, barriers.

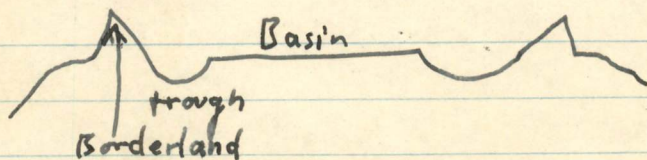
Different condition.

3rd use for fossils - corals in N. Greenland. - it was probly hot ~~at~~ then. They also show topography - sandy living fossils, sandy (clams) - non sand-mud " " (corals) non-sand-mud. ~~Clear~~ Clear waters away from shore, sandy waters near highland, etc., etc..

2 remarkable localities for paleozoic seas - Appalachians & Rockies. Stayed longest in App. They were troughs.

After troughs were filled, water spilled onto central basin. Outside each trough was a paleozoic highland, to supply debris. Coarser farther north.

Paleozoic



B. Early Paleozoic Cycle.

1820, W. England, Rev. Sedgwick, walker,
observed rocks, E. Wales, dipped in general to the east.
Contained trilobites. 1830, called them Cambrian.

Mercheson, doctor, observed them dipping to east,
voluminous writing, named them Silurian (W. Eng. midland)
Saw each other often. They worked toward each other,
finally met, disputed who should have strata.

Doc. Lapworth, compromise, discovered unconformity,
then another. Central stuff he called Ordovician.

B. Early Paleozoic. N. America.

Early Cambrian Seas invaded troughs, then spread.
Potsdam Sandstone - N.E. N. Am.

Memorize
underlined
names

Maps.

1. White areas - land. lined areas - deep sea. Stipples,
epicontinental. Dark stipples - thick, coarse, rock.
Coarser on east App., so highlands on east.
Canadian shield, - high, rough.
2. Quebec, resting on basement complex (igneous)
Basal conglomerate, then sand deposited, Lower Cambrian.
then shale.
- 3.

IV B Early Paleozoic cycle

Cambrian

Expansion of seas across central plain, & deposition of Potsdam sandstone. This makes an ideal period.

Ordovician - Trenton Limestone (Trenton Falls, N. Y.)

Maps.

1. Same as on Fri. - Early Cambrian
Rockies now go east of old trough. But upper Cambrian Seas went east.
2. Newfoundland area.
eroded igneous basement complex. 25° dip.
Then basal conglomerate (has fragments of basement)
" sandstone
" shale
" lime
" shale
" lime
" shale

Same sequence as Sedgwick Pond in England.

Names - one rock per genus of trilobites, highly specialized critters. Nothing in ^{their} structures shows sequence in time - just physical geo. shows.

Here there is no unconformity between Cambrian & Ordovician

3. Vermont metamorphosed rocks, once sedimentary sands & shales, schist now.
4. E. Tennessee, steeply inclined bedding planes, Knox dolomite.
5. " - syncline. - must have been under pressure. But it was also shattered, faulted.
6. Grand Canyon. floor of trough, represented Cambrian sea floor, top of gneiss.
7. Unconformity, a milestone.

8. Rhythmic advance & retreat of seas.

Map - Rockies, App, + Midwest & Texas flooded.

Potsdam sandstone deposited. Potsdam, N.Y.

9, 10. Ausable ~~Chasm~~ in Potsdam sand. - in a joint plane.

11. Slightly undulating layers, showing ~~in~~ literal currents.

12. Garnet & magnetite grains in bottom of ripple marks.

Long slope, ~~from~~ cross side.

13, 14. Dells of Wisconsin A. - sand delta.

Miss. & ~~App~~ has mud delta.

Col. has sand delta.

15. Map - High & dry end Cambrian, then Ordovician seas.

Trenton limestone. - mud & calcareous ooze.

16. Trenton on basement - either Camb. eroded away,
or never inundated in Cambrian times

17. 8 19

20. Shallow water Ordovician deposits. mud cracks & ripples.

21. Slates - slaty cleavage not bedding planes.

Always evidence of shallow water deposition in sedimentary rocks.

Limestone generally interbedded with shale, its strength makes falls.

Mather - Feb 11

Tell Rogers
you can't see him.

VB Taconic
~~main~~ disturbance at end of Ordovician

Pictures

1. Sea withdrawn, due to disturbance. Only one way for volume of oceans to occur — refrigeration. No suggestion of this at end of Ord., so it must have been lowering of sea floor or elevation of continents. No angular non-conformity — just disconformity, which is not angular.

Ord. disturbance involved crustal crumpling. — sand & shale at different Ls.
Taconics — west of Berkshires. Not formed by this disturbance.

2) 3 episodes

1) Local

2) General withdrawal of interior seas.

3) Mid-Silurian times, troughs fill again. (2 great islands, explanation in Tac. disturbance.

Cincinnati arch. ^{on a line} 1000 miles wide. Few thousand feet high — slight slope. N.E. long axis.

Dome making

Extension — Nashville dome.

Never since Ordovician has Cinc. been submerged.
Nashville under in Devonian & Miss.

Northern seas have corals — isolated.
Provincialism to cosmopolitanism &c.

3)

4)

5) Mid-Silurian. earliest known coral reefs. Polyps used to be rugged individualists, now they live together, but not as apples — each to himself.

6) Coral reefs in W. N.Y.

Gypsum overlies at Niagara.

Aridity in ~~late~~^{middle} Silurian times

Gypsum widespread in N.Y. Rock salt & gypsum together - Gypsum, CaSO_4 , not used by organisms, precipitated with NaCl . Satin spar Gypsum.

Arm of sea must have been cut off & evaporated.

E. Great Lakes was great fm. desert, late Silurian.

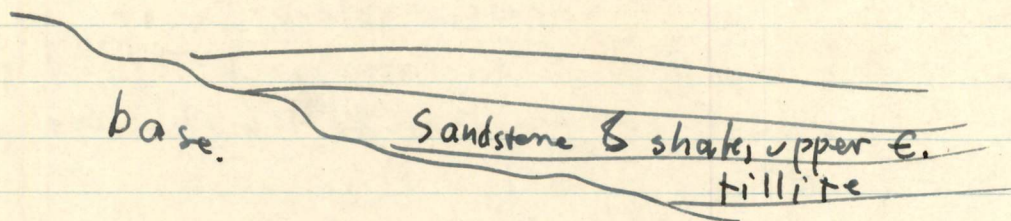
Same in Europe, local aridity. Something had happened to upset climate of earth. Maybe great mts, like Sierra Nev. keep Arizona Arid zone.

Trenton lime
Niagara lime

Angular break between Paleozoic & Mesozoic

Other continents - Glaciation in China, Africa, & Australia.

E = Cambrian
C = Carboniferous
K = Cretaceous



Paleozoic is marked in all continents by rhythmic advance & retreat of seas.

V c The Caledonian Revolution

1. In Europe

Later Silurian, changes of climate forecast great upheaval.

old Red Sandstone
Catskill Formation

1.) Scottish Highlands.

Mid Silurian — Mid Devonian

disconformity, date of mt. making.

2) Vertical Sil. limestones, unconformable cong.

higher ^{old} red sandstone (there is a new one)

Marine & Fresh water fish. Deposited in fluctuation

from wet to dry season. (annual). Coastal plain,

~~changing~~ fluctuating strand line. Caledonia, (Ireland

across Scotland to Scandinavia) affected. Greatly pl. A.

Upper old red is shale, occasional sand. - maturity to old age.

3).

4.) Transfer to N. Am. Devonian period.

3 provincial seas.

Middle Devonian, seas advance cosmopolitanism. partly.

Green sea, marine invertebrates.

early Upper Dev., complete cosmopolitan seas

Shifting seas help heredity progress.

2 regions of thick sediments in both troughs.

5) Tennessee, coarse sediments, showing mts nearby.

6) Devonian front range of Rockies. Limestones.

7) Catskills, flat lying sediments, maturely dissected. N. Am. equivalent of old red sandstone. Red brown cong. sand, fish & plants (oldest known tree)

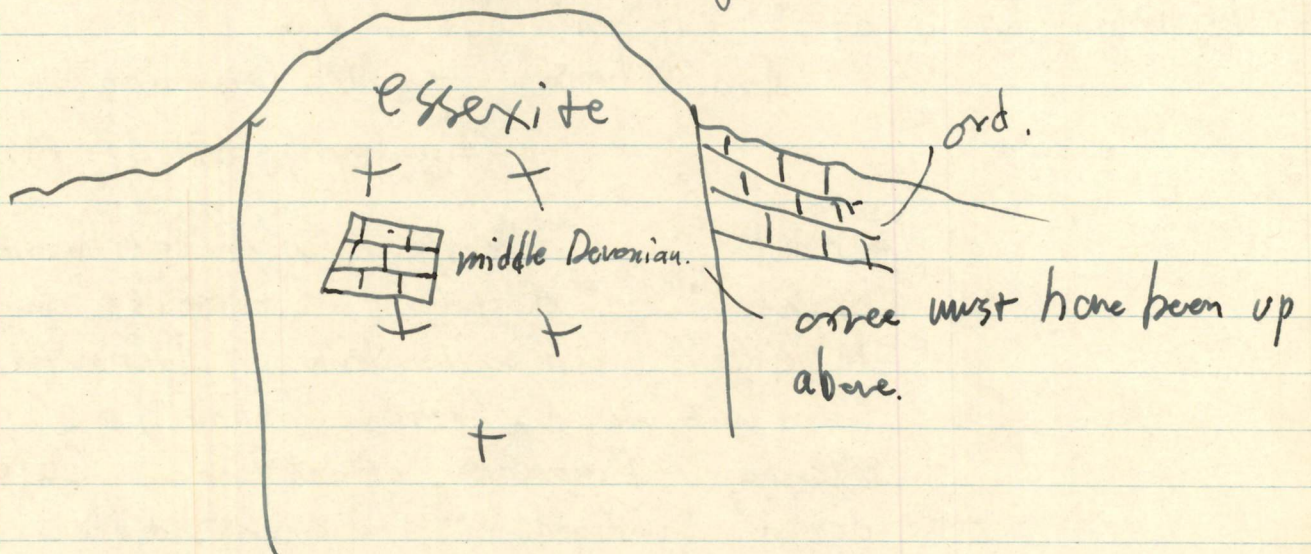
8) White mts.

Lower Middle Dev. sed.

Late Dev. batholithic injected. Acadian Mts.

New Eng. granites many of Caledonian Age.
Blue Hills ~~Pres.~~ range.

Monkroper
Mant Royal Curve of hills. Essexite. - once molten.
Tunnel thru ~~Mant Royal~~ Mant Royal



Vulcanism characteristic of Cal. rev.

VI

D. Later Paleozoic Cycle.

1. In N. Am.

Black mud - Chattanooga Shale

Roxbury congl. in Boston.

Coal measures in Mississippian.

Shifting seas of Miss. pd.

Maps & pitchers

1. Map. Caledonian revolution, affected top, made mts. in N. E., no seas there later (till much later)
Mississippian - S. App., Corn belts, &

Rockies folded, Chatt. shale laid. - most widespread thin Permian. Conspicuous rock. - black, shiny, thin-bedded. Sometimes called slate, but not so. Contrasts with surrounding limestones, etc.

organisms took ox. at belt carbon.

Rigorous, black muds settling in Baltic, few currents & waves. Oxidation of organic ^{matter} slugs, such stuff - ^{carbon} found in Chatt., so it must have been deposited in shallow, land-locked seas. Chatt. shale smells like oil, etc. Seasonal fluctuations twist wet & dry, as in Catskills, must have been tropical. Miss. valley, this shale basic everywhere. Potential source of ~~the~~ petroleum derivatives. Terrible volume of it.

Then water became clear enough for lime secreting organisms,

2. Thompson Canyon, Miss. lime, very pure. Spot was, then very far from shores, or shores were low. Consider always paleogeography, environment at time of formation.

3. N. Platte, Miss. deposits, limestone at bottom.

4. Big Horns, Hog backs, Miss. limestone.

5. Montana,

6. Limes disappear beneath surface - on plains, reappear in Black Hills.
7. Because domed up. Miss. lime widespread. After Cal. rev., long period of stability & extensive seas.
8. 9. Later Miss., seas shift. N. App. flooded, save N.E., which now again was submerged. Nashville dome, & Cincinnati arch still above water, make divide between east & west, dirty east, ^{spnd & shale} clean west. Chert in this limestone, colloidal susp. of silica. Flint ridge, Indians made weapons.
10. Navaho Scotta - lime
11. Sand - N.W. NYC, Marchionni sandstone, Uo. Miss.
12. Kentucky, cross bedded sandstone.
13. Miss. closed, seas withdraw, Grand Canyon?
14. Marble Canyon, Kaibab plateau, Miss. lime.
15. Map. - Pennsylvanian Perm Mississippian separation is terrific. 3rd dome, S.E. Mo., St. Francis Mts.
Swamps in E. interior, coal formed. like modern everglades.
Around Boston, Boston Basin. No oceanic waters, bottom above sea level, dating must be by plant fossils.
16. Coal measure swamps.
17. No flowering plants, but gymnosperms, with resin as sap.
18. Buried mt. range. under Sam. Nob.
19. Wind dep. sands, migrating, borders Lake Penn. sea.
20. Carniel rock, red beds
21. Pack east - Boston basin - Narragansett Bay

Penn. ^{partially drowned.} rock surrounded by igneous.

Mather - Feb 18

VD - Later Paleozoic cycle

1. In N. America

Lime & shale
Lower Carb.

Roxbury
Conglomerate

Roxbury conglomerate.

Maps & sketches

1. Narragansett basin, flooded with Carb. rocks,
surrounded by older carb., synclines & anticlines

2. Congl., equivalent of Rox. in Boston. (Leiden)

Sandy matrix, irregular bedding planes.

Torrential fan, piedmont alluvial plain.

3. Interbedded with sandstone.

4. Distorted sand. - slightly metamorphosed.

Very late Paleozoic.

5. Boston

Cambridge slate & Rox. cong. varying.

Roxbury cong. tops anticline

Cambridge slate tops syncline.

Local expression of Appalachian revolution is
folding under Boston.

6. Wavy Cambridge slate, Penn slumping of mud.

~~What~~ ~~for~~ Talk.

Late paleozoic in Europe.

Here carb. was applied, over Devonshire. Shale & sand
with coal seams. - coal measures. Carboniferous.

To west, N. Wales; intervened twist Dev. & Carb.,
limestone, conforming with Carb. & included, but then
found unconform., so limestone & shale called lower carb.

Miss. - (of N. Am) = lower Carb. (Eur.)

Penn. " " = upper " (")

Widespread swamps, Eng. Wales Belgium
France coal made at same time as American.

Appalachian revolution includes Permian period.

Donetz basin coal bearing rocks ~~over~~ underlie
sandstone, salt, & shale. Perm district, Permian
from this.

Overlying Penn. coal measures, are thin beds
which = Permian, & are so named.

West Texas, & Indian Salt Range, are best
Permian records.

Grouped Permian, Penn., & Miss. as epochs,
called them Carboniferous period.

They should be periods.

Can be called epochs because in many places
Penn. & Perm. are unseparated by ~~non~~ conformities.

Permo-Carboniferous means we cannot tell which.

App. rev.

Trough to App. Mts.

E. S. Am., mts.

Alps in Eur.

Uplift of eastern half of ~~the~~ interior basin.

Cal. rev., Acadian Mts.

~~Ordovician~~ Arbuckle, & Wichita Mts, App. structure.

E. $\frac{1}{2}$ N. Am. so hoisted that now again has Ill.

etc. been under. Pa. dog. Rockies trough unaffected.

App. - Bedford, Pa.

Folding is Permo-carb.

Matter Feb. 20

App. revolution

2. Regional uplift.

N. & Central Europe up - since flooded.
E. N. Am. " " "
(same on borders)

II. Climatic Upheaval

Glacial deposits - Permo-Carb.

19th cent. geologists open-minded - accepted new idea;
Thought late paleozoic was tropical - now know it's
temperate. Late paleozoic ice in S. Africa, ~~to~~ to
southward ice. To north in India - this wrecked
polar ice cap theory. Local ice cap phenomenon, as in
Greenland.

Explanations

1. If equator was in same place, real cold world.
2. Equator & earth's axis in different place.

Ice from S. Brazil to ~~the~~ Bolivia - across
Green Hell. Permo-Carb.

Herzynian - paleozoic Alp - climax in Penn.
App. climax in Permian.

Squawnum tillite formed before Perm.
Herzynian folding changed climate, App. normal-
ized it.

Squawnum
tillite

IV E The App. revolution

2. Climatic upheaval

Permian-Carb. glaciation in S. Afr., Australia, India

Schönberg Squantum Hillite near Boston

Mather - Feb. 25

V F. The Mesozoic Era

Red beds & volcanics of N. E
& Jurassic, next pd.

Pitchers

1. App. revolution - N. Am. like it is now. Mts, glaciation
arid regions.

(Baffin's Land Ice sheet???)

S.W. U.S., Tex, N Mex, etc., late Paleozoic red
rocks, irregularity of bedding. - evidence of Eolian sands.

2. Red beds do not always mean aridity - but combine
with texture & bedding, & aridity proved. Texas pan-
handle - rock salt beds twist & sand, some salt has
potash in it - same, commercial. Shallow sea,
deposits, mg. salts too, "great chem. corp." is
doing it.

Dominant uses mg. - comes from late Paleozoic
deposits of extreme aridity.

Great crustal & climatic upheaval, like present.

Even greater variation

3. N. Am. vast as ~~to~~ today, & as ever.

Triassic deposits - 1) Fundy to Md. to Ga. ~~was~~ - very
sparse. 2) W. Interior - Mo. to Texas 3) Pac.
border trough. Name - S. Central Europe, Stassfurt

Ga., 3 strikingly different rocks - red to salt to
brown sand & shale. - but same structure, no unconformity

In Am, ~~was~~ horizontal trinity

4. Conn. R. - wide flatlands, tobacco & onions 10-30
miles. Uplands - trap & diabase ridges. 2nd area,
around Southbury. Conn. Valley all Triassic.

a) Triassic sediments

b) Traps

c) Conn. Pl. leaves valley

b) Thick lava flow turned cuesta.
Much faulting, so same bed appears many times at surface.

There's also more than one sheet of lava.

Basal Triassic conglomerate on gneiss below.

Road metal rock from Conn. valley.

a) Red beds - sandstones of value as building stones. Trim of this building, e.g. Concrete has replaced, now.
Tracks, fluvialite non marine deposits. Bipedal dinosaur tracks.

c) Geologic history. (Diagrams in Lab. Manual)

Deposition, sinking, squeezing lava up, then faulting, at end of Triassic; App. peneplane then came. End of Tertiary, uplift, rejuvenation & in valleys carved.

Then ice, no very great changes - sanding, etc. Ice debris deposited; Moraine dam, caused change in course of R.

Tobacco on valley trains, great fertility.

Bay of Fundy similar, but submerged.
Digby Cut, Annapolis ~~Valley~~, Acadia. Apples.
Garden spot - Black Mt. does it.

T. sed. & lava, Jurassic folding, block faulting,
Cretaceous peneplane, Tert. trap ridges, glac, valley.

V.F.

3. Comanchean (lower Cretaceous) Martha's Vineyard, W.N. Am.
4. Cretaceous

Coastal

Plain
Series

Comanchean 1. White Cliffs of Dover

Carboniferous, Cretaceous - cause of chalk

Difficult to get good exposures.

Dakota
Sandstone

- 2, 3. Calcareous shells of microscopic animals.

Much pulverized - means shallow water. Widespread shallow seas, divide then discovered. - Upper & lower.

Also in N. Am., in Texas, etc. Comanchean N. Am., start of Comanchean,

Coastal Plain ~~near~~ Gulf of Mex., first sediments ever laid there.

Rocky Mt. trough flooded, end to end.

Pac. border narrowed.

Coastal plain, very poorly compacted material.
Younger rocks near shore.Then, later in Comanchean, invasion of Texas,
Pac. trough, & Arctic.

N. Atlantic coastal plain - S. of New York City.

Fall line - inner border of coastal plain -

Cretaceous early, Martha's Vineyard, chalky.
Gulf of Maine & Grand Banks, recently exposed
Triassic red beds, Coastal plain series.Advancing central sea, Dakota Sandstone, Mex. to S.D.
But not time equivalents. Slow northern advance of sea.
Rim rock of mesa. ~~is~~ Firmly cemented. Many hogback
ridges bordering Rockies.Upper Cretaceous - Complete flooding of Coastal
Plain, great plains. Last great mid-American sea.
Mesa Verde, Mancos Shale capped by M.V. sandstone.

Mather - Feb. 27

Triassic
Red Beds
of Conn. valley

Nevadan
Disturbance

1. Triassic Sed. & igneous. In piedmont. Sigmoidal basin, N.J., Pa., & Md. & Va. All Triassic rocks are basins. Barbara Frietchie in Fredericksburg in "walked by Md. s mts.". Trap masses, more resistant, ridges & hills. Palisades of Hudson such a trap. - Vertical jointing, columnar. Very thick Triassic trap sill. - Beyond palisade ridge, Hackensack meadows. - In hist. of settlement of N. X., ridge was first & western boundary. Cross faults. Newark bay has crossed ridge.
2. Farther South, Va., round, gentle slopes - weak & flat lying rocks.
3. Some poor grade coal. When dike comes through, coke.
4. East, S.W., & Pac. W., strlogy.

non marine red beds. Dep. wearing Permian red beds.

Permian-Triassic in S. Col. & New Mex. & Tex.

Pac. border trough - new element here. - movements during App revolution. - only Triassic marine invasion. Margins of mesas in N. Mex. - reddish brown - Plinianite origin. S. Col., red sandstone on edge, & shales. Garden of Gods near Colo. Sp.

Jurassic over Triassic in N. N. Mex.

N. Am. - Widespread erosion in E. N. Am. in Jurassic. - No Jurassic deposits there at all. Laramie Sea from Arctic in Rocky Mts. trough - separated from Pacific by lofty ridge.

Triassic White Cliffs in S. N. Mex. - extensive cross-bedding - sand dunes. Also some lake beds - fossils of fresh-water fish, Jurassic.

5. Col. n. of Estes pk & Ft. Collins. Jurassic beds fold under plains. Jurassic red beds, near border of Laramie Sea.
6. Pac. Border Trough. Very rapidly accumulating stuff. 30.40 ft anns. Organic materials in sand potential oil.

End of Jurassic - (Mt. Whitney) Cal. near Lake Tahoe

etc. Calaveras Formation & great batholith.
Nevadan disturbance. extending into Mexican lower California.

Mesozoic Era V F

1. Triassic

Red beds & volcanics of Connecticut Valley, Bay of
Fundy, Pa. Sylvania,
Red beds of SW Interior
Pacific border trough.

2. Jurassic

Erosion only in E. N. Am.
Rocky Mt. Allocated
Nevadan Disturbance

Geology - March 4.

V F. 4 (cont.)

Close of Cretaceous - Laramide Rev.

Main series - ~~Alaska~~ Alaska to Mex., Rocky Mt. System
Laramide disturbance here.

Same thing that happened to App. trough happened to Rocky.

Rocky rocks. Named for Laramy, Wyo., Post Laramide
folding. Laramy stage of upper Cretaceous. One huge
anticline ^{over} Rockies.

Western $\frac{3}{4}$ ~~thickness~~ of trough was shared over eastern $\frac{1}{4}$, Alaska
to Wyo.

Laramide disturbance did not completely build
Rockies - later up thrusts from below.

Also hoisted w. $\frac{1}{2}$ interior, just as App. rev. hoisted eastern
part.

Laramide also affected App.

(Triassic - narrow sandstone)

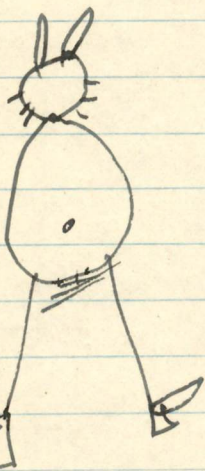
Cretaceous peneplane in Acadia. Then great arch formed,
axis of which follows App. today. Rejuvenation, valleys
carved. Then down tilting, flooding of lowlands, drowning.

N. Alps, S. Black Forest, Vosges, S. E. Asia, Australia,
worldwide Revolution.

Cenozoic era is revolutionary, all. Other revolutions
were not so long lived.

Cenozoic rev. starts with Laramide. Still in it.

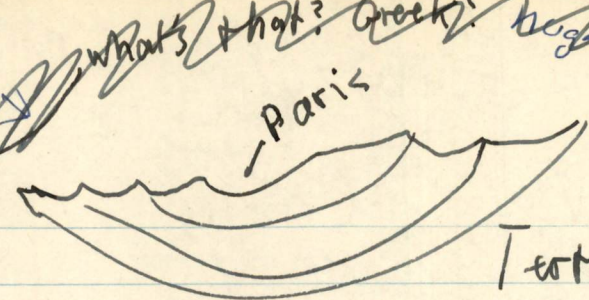
Terms —



Lonell p-21

Paris basin

Yellow
sand
cray



Crumble easily. Good marine fossils.

Lyell sorted fossils from different layers, discovered they were like modern 5% then 35%

Oligocene

Paleocene	-	Early dawn of recent	Tertiary
5% Eocene	-	Dawn of recent	
35% Miocene	-	less recent	
Pliocene	-	Somewhat recent	
Pleistocene	-	More recent	
		Most recent - Quaternary	

180 stg!

Maer - March 6

March 15, exam.

II G2 Tertiary time Approaching modern conditions.

1. Early Tertiary. - like present. Atl. coast under, gulf coast under, pac. coast under. N. great plains, cont. deposits.

East - Paleozoic trough, northern $\frac{1}{3}$ up in Caledonian rev., folded in App. Cretaceous, eroded to peneplane, great Smoky monadnocks, & Pres. range monadnocks, maybe more. Laramide arched whole region, rejuvenated streams.

2. S.E. Pa, Susquehanna, sigmoidal Allegheny ridges. Water gaps. Small anticlines. Susquehanna is superimposed on course on peneplane, which was rejuvenated.

Tributaries are adjusted, subsequent. Smooth crests of ridges from old peneplane. App. uplift was intermittent. - Tertiary renewed rejuvenation.

Top parts of Wash. & Smokies are old monadnocks.

3. Unconsolidated beds. CaPO_4 , fertilizer, in few consolidated beds in south. Now atolose. Most of organic origin. Guano, e.g., contains CaPO_4 . Water trickling thru it dissolves at stuff deposits below water table.

Tertiary Comanchean 4. Beds of coastal plain slope seaward, more steeply than surface. Cuestas. Artesian wells, Atl. coastal plain.

Great plains - Western interior - not under water - piedmont alluvial fans. Just east Rockies much lower than now. Rivers from Rockies lost velocity, loads, there. That's how plains were ~~formerly~~ elevated. Today, western N. Am. uplifted, plains are being destroyed by rivers. Bad lands in Tertiary rocks. Ideal for preservation of land animals.

Intermontane basins - internal drainage. Green R. area built up thus. Rich oil shales, Col. & Utah.

Matter March 9

California - Coast ranges, great valley, & Sierra Nevadas. San Joaquin & Sacramento.

Tertiary, eocene-miocene, uplift. 2 pac. embayments, Gulf & Atl. coast under. Petrol resources of Cal. - Wheeler ridge, s. valley, diatoms make oil. Miocene sandstones, stain of petrol, - interbedding of sand & oily shale, makes this Tertiary oil. Horizontal compression.

Coast range youngest in N. Am. - Pliocene.

Course of mt-making is westward. Overturn folds.

climax of
volcanism

- S.W. Cal, San Juan mts, volcanic, miocene.

End of Tertiary, this peneplaned. Then, vertical uplift, warping & rejuvenating. Streams cut to temp. base level, then a new uplift, still being cut into.

This volcanism preceded by glaciation. - eocene tillite. (which just anteceded revolution). Then volcanism.

Yellowstone, Tertiary volcanic. Mt. Hood, Mt. Rainier, Baker, Shasta. Crater Lake, head of volcano knocked off in Pliocene. Sierra Nevada, near Fresno, broom capital; eastern edge of Sierra fault block, (16,000 ft. wall). Wasatch mts. Utah, 7,000 ft. wall. Great basins stretched - series of long, straight faults, mts.

Renewal of crustal movement in App.

End of Tertiary, Pliocene, nearly like present land area. Florida newest. But St. Lawrence & Hudson bay up.

Europe & Asia. 4 shields, no crumpling.

Some intermontane basins.

Alps Miocene.

Pliocene, Himalayas.

Hour Exam., N.H. Hall, Wed. at 12. Lab.

V G 3 Quaternary time

White mts., local Alpine glaciers before cont. sheet from Laurentian centers got there. Couple of cirques. Trough between Greens & Adirondacks. Ice retreated by down-wasting from above. Drumlins left. Esker. Ice-contact ^{melting & evap.}

slope.

Recession of Wisc. ice in interior. Terminal moraine thru Summit, N.J., Penn, N.Y. above ~~middle~~ Erie. At N.Y.C., beneath Hudson valley, etc, moved farthest south. W. N.Y. in "shadow" of Adirondacks.

West, Illinoian is pre-Wisc., went a little farther. Many recessional moraines. ~~Moraine~~ In recession, lobate character of ice emphasized.

Hist. of Great Lakes - Valparaiso moraine, last recessional moraine around Chic. Thru "the sag" it drained. "Lake Chicago" in existence, over Chic.

Then Mich. Lobe retreated, Lake Chic. enlarged, same outlet. But L. Maumee drained in Chic., called Whittieray.

Then Mohawk Valley uncovered, (today its higher than "sag", but then lower, since a tilt from the east) Lake Algonquin. (Superior, Huron, Mich. connected)

Trent R. connection between Alg. & ~~Erie~~ Ontario for a while. There are changes (2 narrow sections) in Niagara gorge, when only Erie basin water came this way. Rise in land elevation stopped Trent R.

Also a pre-Wisc. buried gorge - pre-W. Falls, too. Gorge now full of drift.

When St. L. valley free, L. Nipissing - Ottawa R. outlet. Because land still down, St. L. drowned. More straight along Champlain, shore features there now. This was 15,000 years ago. - men here.

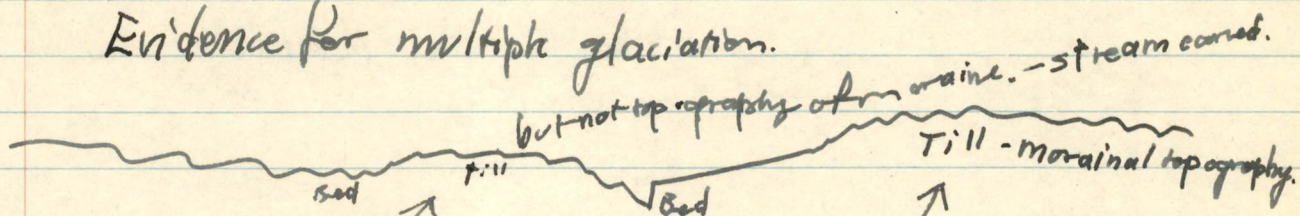
Post-Nipissing tilting.

Then tilt up n.e. for feet, to present conditions.

Glacial Lake Agassiz. As soon as ice got
North of finds, Lake started, got bigger & bigger, draining
the red river, wheat lands there. Then Nelson R. exposed,
lake drained to Winnipeg.

Mather March 13

Evidence for multiple glaciation.



Materials different. 3 ft. of weathered till, chemically. - soil, i.e. 10-12 ft. weathered till. Also, limestone grand up in till - it's soluble. Deposits are "leached". 15-20 ft. vs. 3-4 ft leaching.

But above all explicable with one glacier.

But beneath moraine front, are found loess etc., then more moraine.

Nebraskan drift = New Jersey drift.

Kansan drift over it. - Iowa. Gumbo clay - sticky & stiff.

Illinoian drift in Ill. & Ind.

Wisconsin drift. Iowa drift is earliest Wisc.

4 stages Neb - N.S.

Kans

Ill

Wisc

W. Wisc., driftless area. Devil's lake, quartzite rock. Driftless area near iced. If stood high.

Mass. & Conn. & Long Island glaciated. Moraines along L. E., Narragansett Bay, Cape Cod.

N. of Plymouth - most s.w. states.

Mantha's vineyard, moraine, boulders Penn Marine. Slopes to south, moraine & plain.

Sanwich moraine & Buzzard's Bay moraine. Mashpee plain between them. - Valley train next Cape Cod Glacier, B.B.G., did it. Blocks stayed long enough for erosion to happen. End then drowned.

Contorted beds show readvance of ice.

Terminal moraines - L. L., Nantuxket, M. & V.,
Precessional Moraines - B. B., C. C., etc.

March 11

Tertiary time

Cont. rel.

Migrations of continents. Evolution of land animals influenced by intermigration opportunities. Africa & Eurasia contiguous. Australia isolated, ever since Laramide. N. America, Tertiary, connected sometimes to Scand. & Siberia. S. Am. isolated, but betimes connected with N. Am. & i', with Europe.

Caribbean Arc connection more important than Panama. Yucatan thru Cuba to ^{thru Ant. Ills} Venezuela. In Paleocene, a land connection over it - Caribbean a Pacific gulf. When this was sunk, no gulf stream, climatic effect, end of Tertiary. Late Miocene, Isthmian Bridge appears, never sinks since. Conical climate, universal, palms & pines grow together. Thruout Tertiary, climatic zoning became marked. Glaciation to come

Climate

Quaternary Period. (Pleistocene & recent) but recent pleist.

Irregular hummocks & mounds, loose unconsolidated material. Contained tertiary fragments, called quaternary. Glacial erratics.

Called glacial till Moehchi deposits. Iceberg theory for scratches. 18th, Agassiz, glacial theory. 1831, someone else got same idea, but obscure. Aitiche & discussion. Agassiz's relation, Copper in Lake Superior &, donated to Harvard. At Agassiz Cliff, Edinburgh, overhanging ledge, strias under it. Direction of ice discovered by unique rock distribution.

Laurentian (Labrador) ice sheet, center in Quebec, Laurentian plateau, Huron gulf & Hudson Bay.

West of Hudson Bay, Keewatin ice sheet

Series of centers in western mts, Cordilleran sheet.

Ice did not get to Alaska.

Laurentian ice sheet - winds & i. snow from S.W., so it moved that way.

2nd revision to Agassiz - irregular deposition of till, & on the other hand, dendritically drained, regular, non-glacial surfaces. - difference in time of deposition does it.

Sometimes 2 bodies of till, separated by sand etc.

Why? At edge of glaciers, alternate advance & retreat. But here this does not work, because there are orange leaves in strata, which don't grow in cold. So there were 2 stages. Pleistocene time divided into interglacial stages.

STRATIGRAPHY OF THE BOSTON AREA

PLEISTOCENE
(erosion)
TRIASSIC

* GLACIAL DRIFT, till, outwash
cretaceous peneplane
✓ MEDFORD DIABASE & TRAP DIKES

Pine Hill

PERMO-CARBONIFEROUS

Peabody, basin produced.

✓ Tufts Quartzite, 40 feet

✓ Cambridge Argillite, 3500 feet

✓ SQUANTUM TILLITE, 50 to 600 feet

arkose lenses

✓ ROXBURY CONGLOMERATE, 1300 to 4000 ft.

(Pennsylvanian?)

Nantuxet

✓ Mattapan volcanics, 0 to 2000 feet

DEVONIAN (?)

✓ QUINCY BATHOLITH, hornblende granite

Nahant Gabbro

Salem

CAMBRIAN

Green Lodge Formation

Braintree Slate, 1000 feet, fossils.

Weymouth Formation

PRE-CAMBRIAN

✓ SALEM GABBRO-DIORITE BATHOLITH
✓ DEDHAM GRANITE BATHOLITH

✓ LYNN VOLCANICS, rhyolite, felsite

Pine Hill

✓ WESTBORO QUARTZITE

*Pine Hill - met. by
bedrock.*

✓ WALTHAM GNEISS - *Blueberry Hill*

NORFOLK BASIN

PERMO-CARBONIFEROUS

✓ WAMSUTTA RED BEDS

✓ PONDVILLE CONGLOMERATE

✓ GIANT CONGLOMERATE

(BASAL ARKOSE)

*Blue hills complex, which
Sed. ed into* →



Sketch Map of the Boston Area

Scale: 1 inch = 3 mi.

Broken lines indicate faults

Cambrian

Troughs Flooded. Then west. int. basin flooded, app. trough dried. Then West uplifted, whole east Flooded, Potsdam Sandstone laid, n.e. N.A. Limestone too. Green Mt. disturbance, seas out.

Ordovician

Trenton Limestone, Long uneventful submergence

Taconic disturbance. Elevation, little folding. Cinn. arch & Nashville dome.

Silurian

Niagara limestone. Corals in arenic.

Then Salinan gypsum & salt. Aridity. Redbeds.

Then Flood, which dried to dolomitic limestone, then normal conditions.

Caledonian revolution (Sil. & Dev)

Cal. mts.; Acadian mts. folded, batholiths. Overthrust in them. Okla. & Kans. folds. Volcanism in all. Ice in north. Holarctic cont. St. Lawrence Valley up. (E. trough slightly up.)

Devonian

Europe { Caledonians eroded. Old Red Sandstone deposited. Aridity.
Then a flood, low, swampy shores, coal.

America { Restricted seas. Then flood over whole basin. Catskill Formation
a congl. sandstone, red. W. N.Y. etc, thick black shale.

Chattanooga

Mississippian

- Eur. { "Culm" phase, coal on shores, lime in middle. Then borderlands rise, shale & sand in Eur. ~~Then~~ ~~the~~ Hercynian mts. rise.
- Am. { Quiescence & submergence. Gypsum in Acadia, St. Lawrence. Flooded too. Less arid climate. Basin submerged, Pocomo sandstone & Miss. limestone. Beginning of trough folding.
- Uplift.

Chatt. shale

Permian

- Eur. { Russian limestone seas, w. even swamps, coal. Subsidence. Western sea, swamps & coal in east. Boston basin.
- Am. { Squawton tillite (Permo-carb.) Roxbury Congl.

Permian

- Eur. { Cal. & re elevated. Hercynian's high. Europe arid. New Red Sandstone (Then mg. limestones, mg & K deposits. Cu, too. Stassfurt.
- Am. - Gypsum in Kansas. Cont. red beds.

Appalachian revolution (Penn & Perm.) (greatest rev.)

Hercynian in Europe. Glaciation in India. Acadian uplift. Whole App. trough folded to mts. Ozarks & S. Rockies contiguous, similarly affected. E. int. basin up, never again down. Squawton tillite near Boston. Trough w. of Rockies, S.V. to be.

Triassic

Red Beds of Conn. Valley, & trap rocks. Transitory climate corresponds to red sandstone. S.W. U.S., eolian red beds. - & rock salt.

Jurassic

Erosion & cont. dep.. Coal measures. (Eur) None found in e.n.a. Upl. A & Nevada disturbance. Bath. intruded. Minerals. New trough to west, ~~the~~ Coast. Range to be. (Conn. valley disturbance)

Cambrian

Erosion, s. coastal under, n. c.p. up.

Cretaceous

Tropical north. Peneplane. Present e.n.a. result of uplift & erosion in this peneplane. Dakota Sandstone. Tampico oil. Limestone in east.

Cenozoic Era (Revolution)

Paleocene (Laramide or Himalayan, 1st active phase)

Uplift, worldwide. Mt. making. App. had been peneplained & made. West. trough folded up. At. coast like "com." West. mts. lowered by erosion. Swamps & coal on plains. Col. plateau flows.

Early Tert.

(Eocene, oligocene, miocene)

2nd active phase. Cascadian & Alpine, Mio, pliq, pleist.

Great west. uplift. Overthrust faulting in Laramide W. ranges, n. Rockies. Cascades & Coast Ranges up. Worldwide uplift. Pleist. w. volcanism.

Pleistocene glaciation

EXAMINATION BOOK

Name Mason Gaffney

Date Mar. 18

Subject Geology I

Section Marne, Fri. P.M.

1-9

2-9

3-8

4-9 1/2

35.5
89

B

**Do not tear out leaves
from this book.**

1. Niagara limestone. Silurian period, Paleozoic era. Widespread seas in the eastern interior basin, ^{of n. America} with rather low bordering mts., so that the seas were not loaded with mud, sands or pebbles, but were clear, ^{+ warm} so that lime-secreting organisms could work.

Catskill Formation. Devonian ~~in~~ period, Paleozoic era. In the Caledonian revolution, just preceding, the Acadian mts. of New Brunswick, Nova Scotia, ^{& farther south in N. Eng.} etc., had been formed, folded and overthrust, and elevated high. These mts. intercepted the moist breezes from the Atlantic, so that the e. interior basin was quite arid. The youthful streams brought pebbles and sand into the area, where the iron in them was oxidized, ~~giving~~ giving the red color to this formation. It is a sandy conglomerate.

- 1/2 Potsdam Sandstone. Cambrian. The Appalachian trough was filled from the Pacific, by and erosion from the eastern borderland filled it (& the ^{eastern} interior basin, in part) with sandstone. *marine dep.*

Dakota sandstone. Cretaceous, period, Mesozoic era. Mexico had been flooded in Cretaceous time, then this sea, in Cretaceous, slowly worked northward, in a broad belt about the same as the great plains, today. The App. revolution, preceding, had moderately elevated the western trough, and erosion from it into this sea, as it went north, produced Dakota sandstone.

- 1/2 Chattanooga Shake. ~~Carboniferous~~ ^{Miss} time, Paleozoic era. E. North Am. ~~Either~~ ^{The} beginning of the App. revolution, ~~or the~~ ^{as} was folding up the App. trough, and it was

still quite low, so that a black sea prevailed in the e. int. basin, full of mud, and organic matter. This sea was excluded by the App. uplift of the whole area, and a black, organic shale, thin bedded but thickly deposited was left. It is a potential source of petroleum.

- 9 2. The Nevadan disturbance, at the end of Jurassic period, was a tremendous ~~the~~ extension, fault block mt. making, and batholithic intrusion, ^{No - this much later} but there was no worldwide activity at the same ^{time} - it was isolated in time. (The Conn. valley faulting was Jurassic, too, but that is minor)

The Appalachian revolution, ~~at~~ in which the whole App. trough was folded and uplifted into high mt. ranges, was of worldwide significance.

In Europe the Hercynian Alps were folded ^{re-elevated} ~~elevated~~, the Caledonians were re-elevated, and a whole string of mts., all the way across Asia to the Himalayas (not at max. uplift here) were produced. In Australia and Africa there

was activity. ^{What kind?} Compared with these phenomena, the Nevadan disturbance was a local affair. In making arbitrary divisions in time for the geologic timetable, ~~or world-wide~~ which aims to cover the whole world, worldwide phenomena must be taken to mark the grand divisions.

Climate?

Thickness

3. Columbia lava field. This field ~~is~~

represents, ~~also~~ next to the DeKkan in Africa, the greatest volcanism in earth history. It is in S. Idaho, E. Oregon & E. Washington, mostly. It occurred early in the Cenozoic revolution, in the first (~~Eocene~~ *Eocene Oligocene* ~~Alamogordo~~ *Alamogordo*) active phase of it. The lava is slightly weathered in some places to a soil which grows wheat and is responsible for the great northwestern wheat fields. The Snake and Columbia rivers cut this plateau. This volcanism is significant ~~what~~ usually occurs in the volcanism that

It is a series of lava flows, still horizontal, on top of each other.

*not quite
pressure flows*

the great mt.-making revolutions. ^{horizontal} Pressure
folds in a great anticlinorium a group of
beds, and pressure is taken off ~~mag~~ rocks
below, thus lowering the melting pt and causing
some of them to go to the surface, or be intruded
just beneath it as batholiths.

4. The Great Lakes.

In Pleistocene time there was a great
glaciation of the northern $\frac{1}{2}$ of North America.
~~When~~ There had been, before the glaciers, a divide
between the Laurentian and Mississippi drainage
systems, which the ~~glac~~ ice covered but did not
destroy. The last terminal moraine left
contributed to the height of this divide, and as
the glacier retreated downhill past the last
moraine (Valparaiso near Chic) a lake began to be
formed between, which found an outlet over
the moraine, in what is now the "sag". Lake

Chicago was formed over that city of today, and gradually advanced northward. Similarly with Lakes Superior, Erie (Maurice).

Then Maurice began to flow into Lake Chicago & thence to the Miss. But when the Mohawk Valley was uncovered, being at that time lower than the "sag," ~~it~~ & the water drained at there. Finally the ice retreated far enough so that the St. Lawrence (drowned as it was) valley was opened, and Lake Nipissing (as Mich-Huron-Superior combined was called) drained thru the Ottawa R. to it. The weight of the ice had lowered the area, and when it was gone the land ~~was~~ sprung up, and the O. H. R. passage became too high. Then the Trent R. thru Mich. became too high, so finally it flowed into Erie, ^{over} Niagara, ~~as~~ thru Ontario to the St. Lawrence. ~~The~~

Variations in width of Niagara gorge

