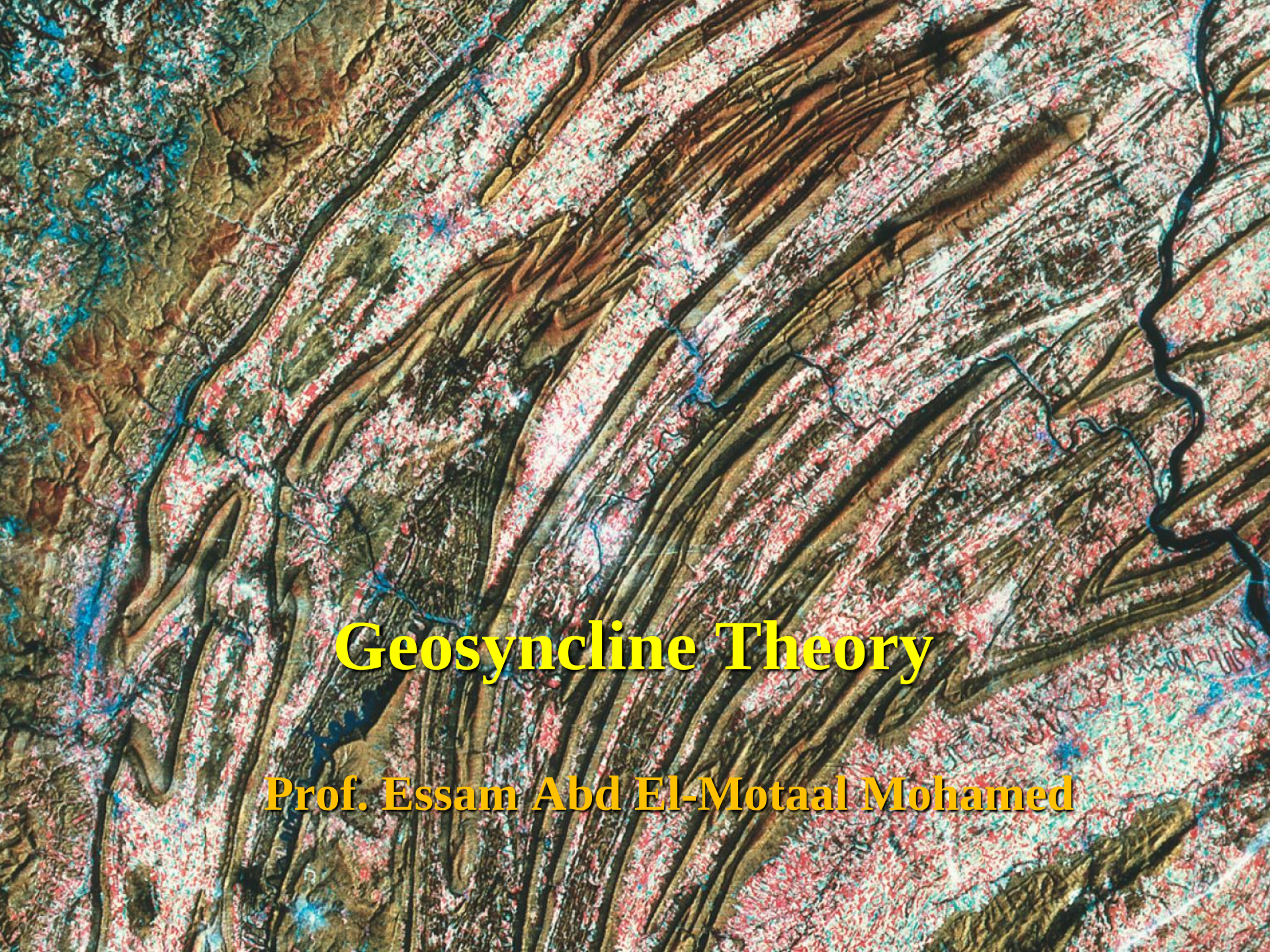
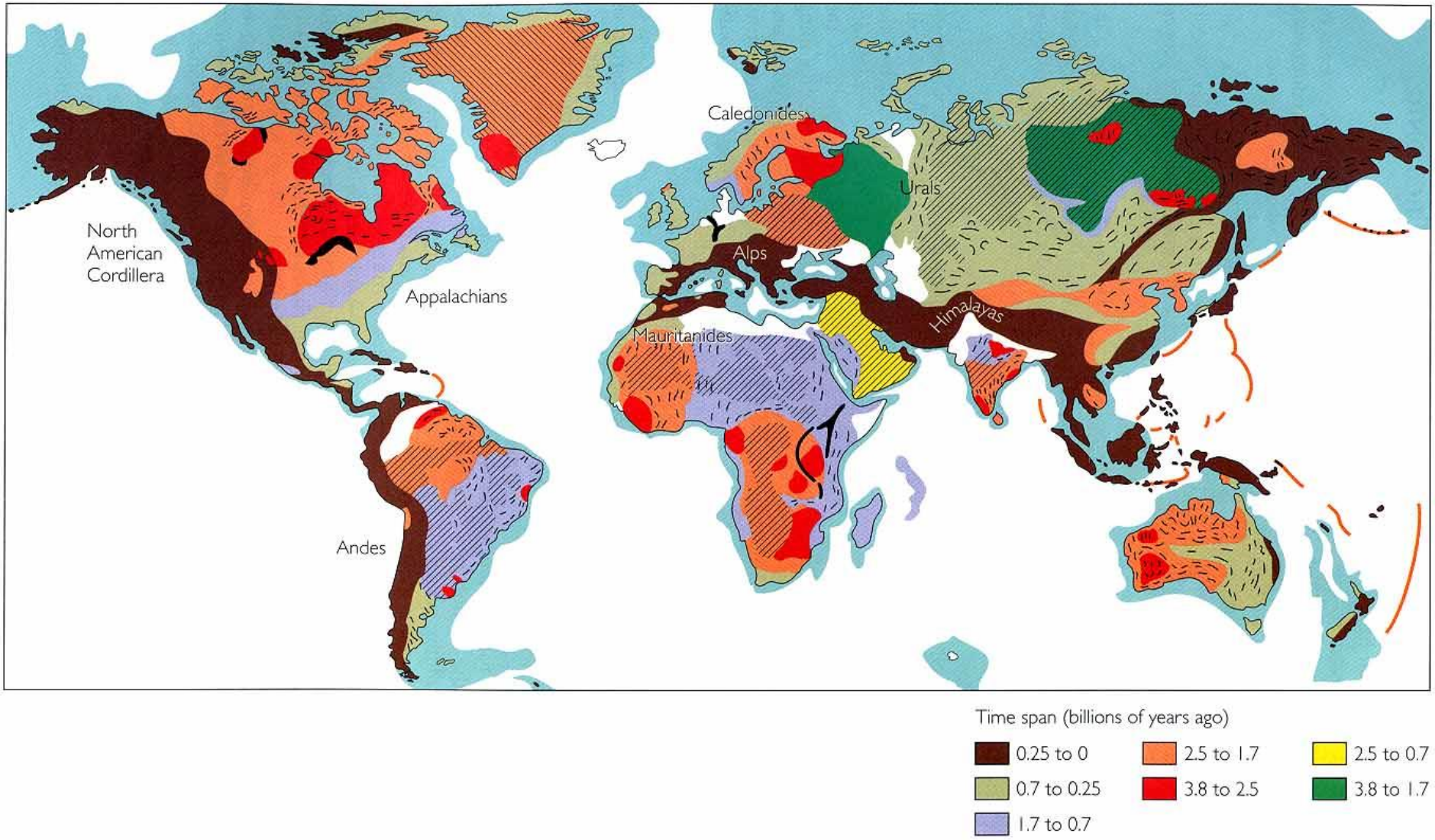


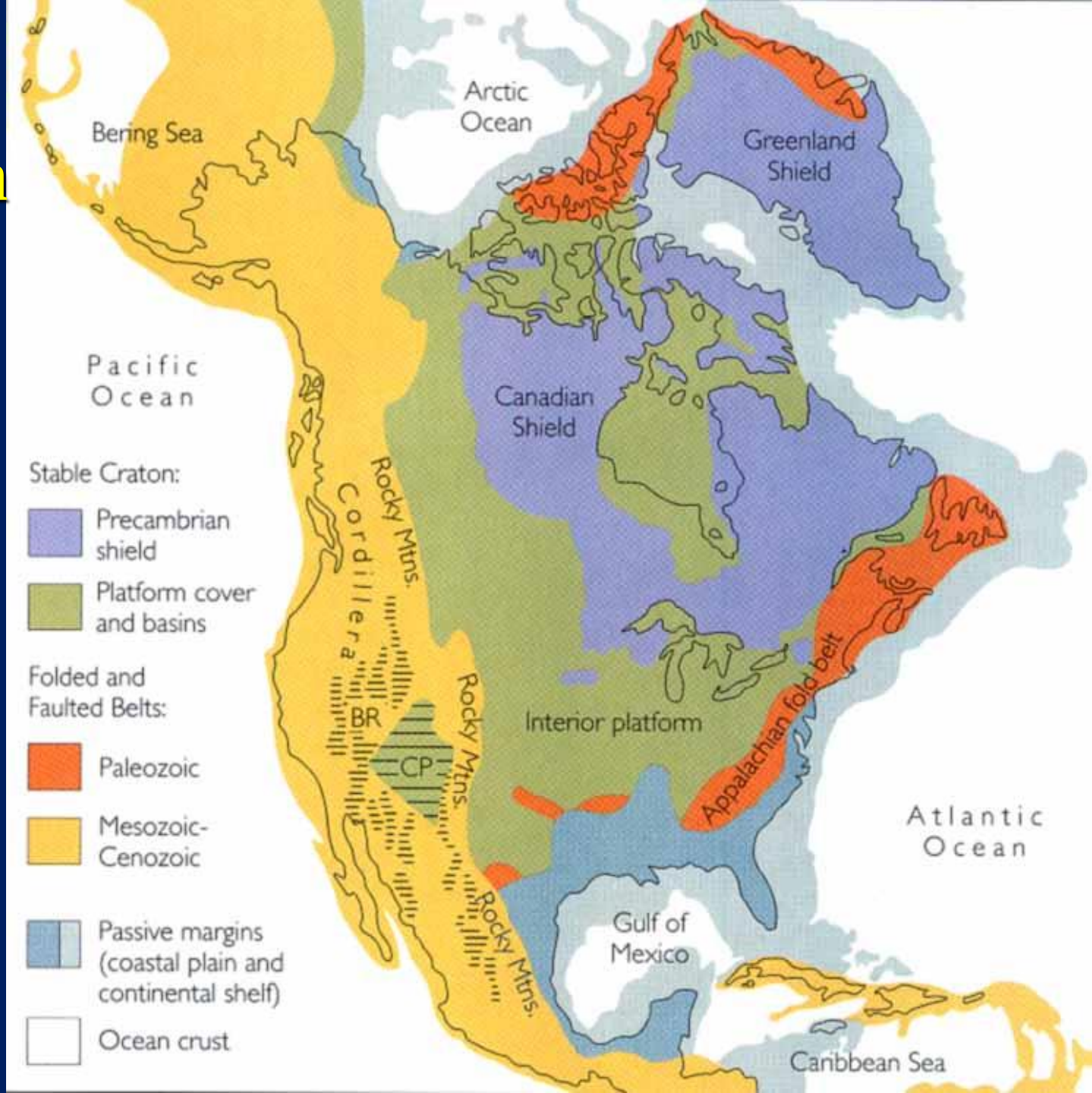
Geosyncline Theory

Prof. Essam Abd El-Motaal Mohamed

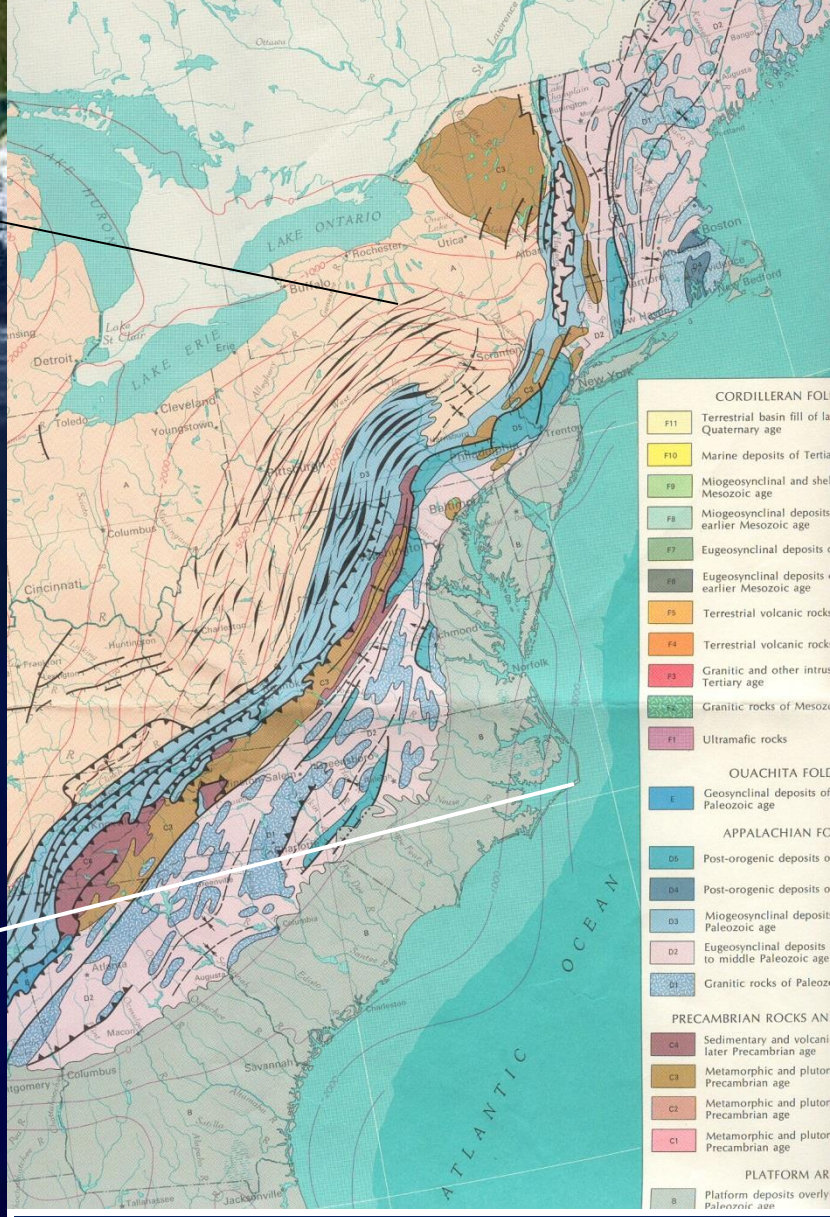
Mountain Belts



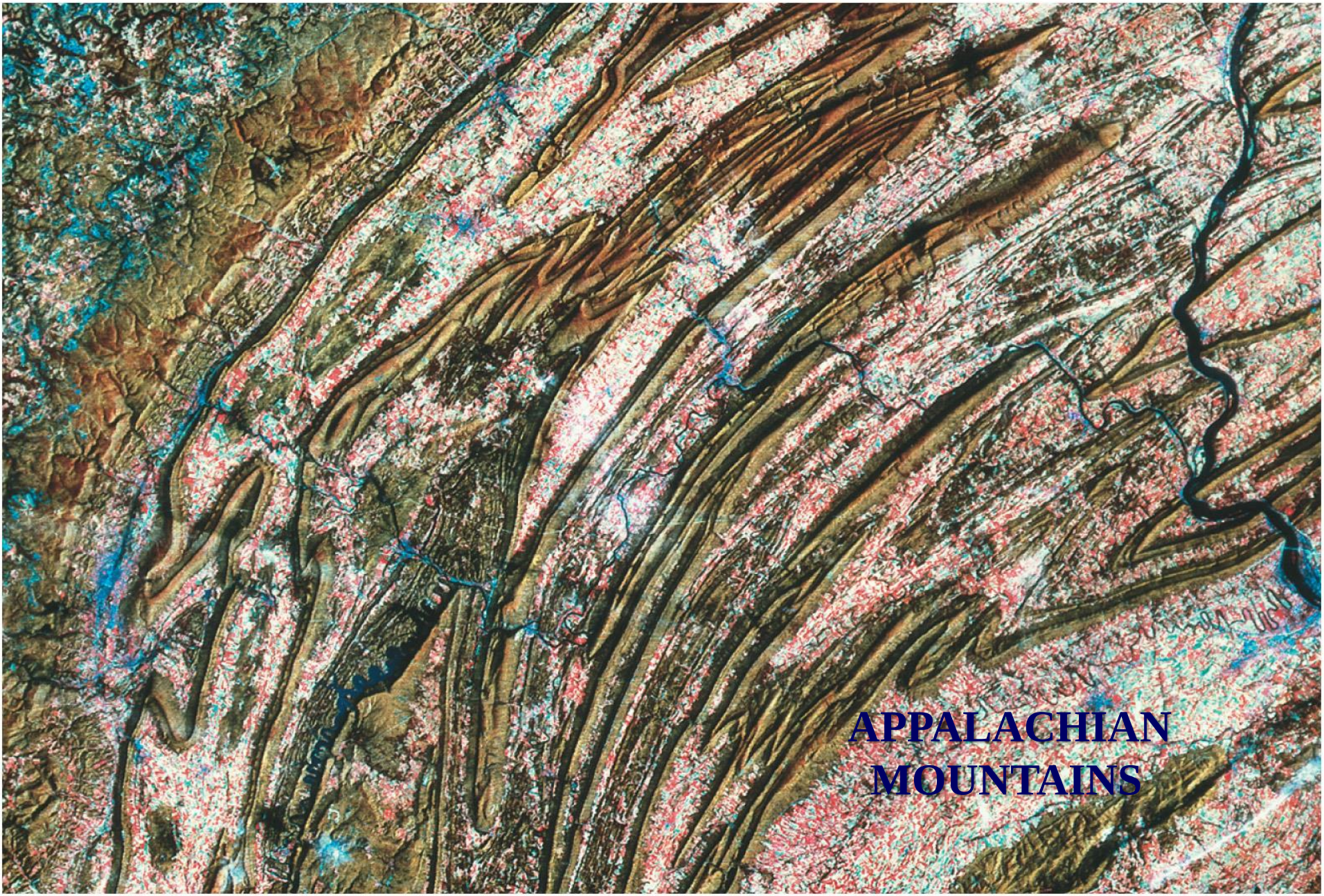
Mountain Belts



Folded mountain



APPALACHIAN MOUNTAINS



Appalachian Mountain belt

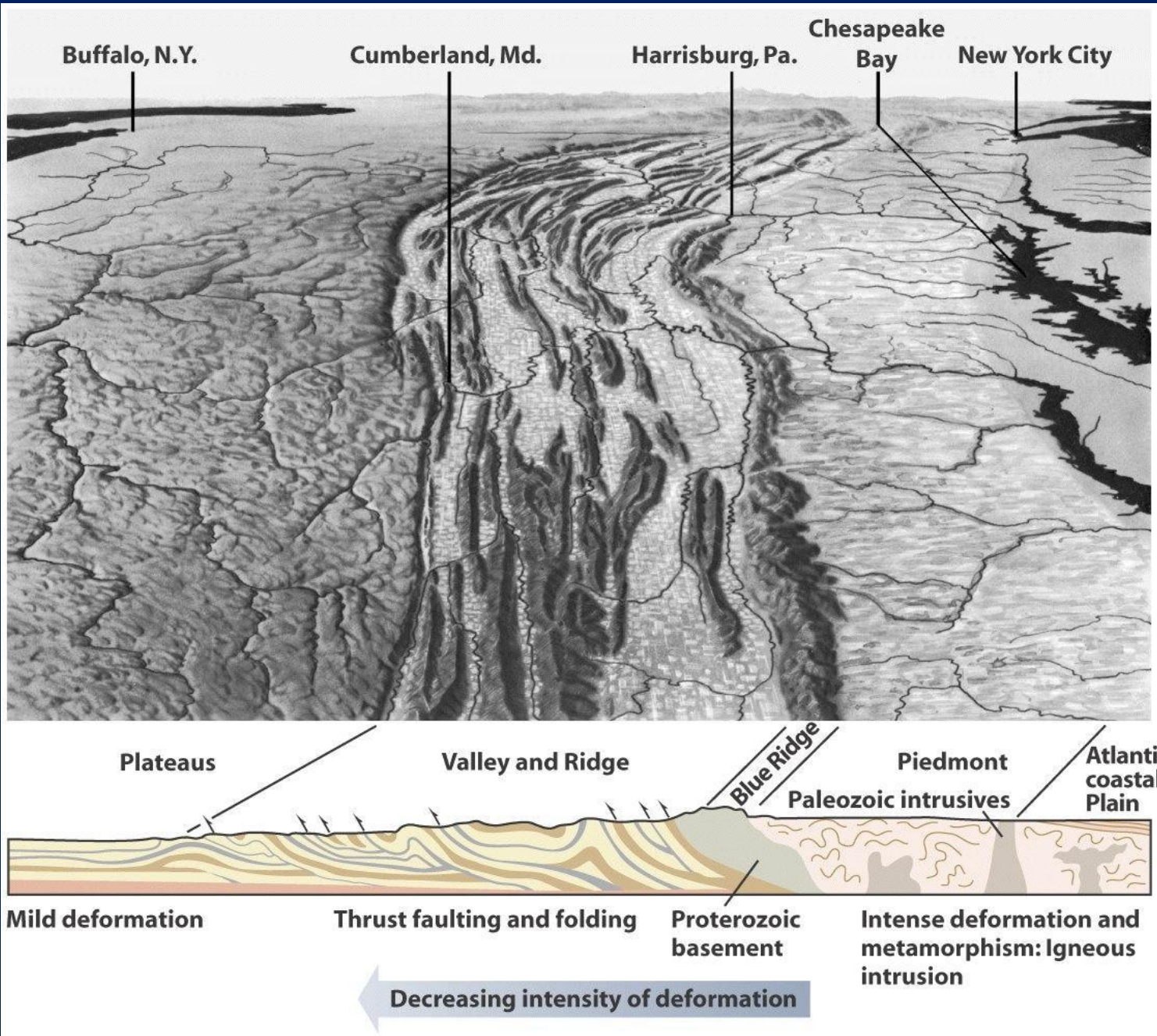


Figure 15-20
Earth System History, Second Edition

Geosynclines

- An interesting early concept in regional tectonics was that of **“geosynclines”;**
- It aimed to explain **orogenic belts** that are highly deformed regions of the Earth’s curst that appeared to have been sites of great amounts sedimentary deposition before being pushed upward, shortened and commonly experienced metamorphism and melting;
- Called “geosyncline”, because it required the development of a syncline-like depression to start with;

Geosynclines

Geosyncline: a belt in the earth's crust that subsides for long periods so that it acts as a collecting basin for sediments eroded from adjacent uplifted areas of the crust and for lavas and ash erupted from fissures and volcanoes.

- When the geosyncline becomes unstable, its sedimentary filling is deformed, metamorphosed, granitized, intruded, and eventually uplifted into mountains.

Geosynclines

- The concept was developed by James Hall
  - – New York paleontologist
  - – Based on his observations of rocks in the Appalachians
    - Noted that folded layers of rocks in the Appalachians were thicker than sediments are nearby continent
    - Deduced that sediment accumulated in trough-like depressions
    - Hall never explained why these troughs became uplifted into mountains, but believed that the amount of uplift was related to the amount of sediment
    - "Theory for the origin of mountains with the origin of mountains left out."—James Dana

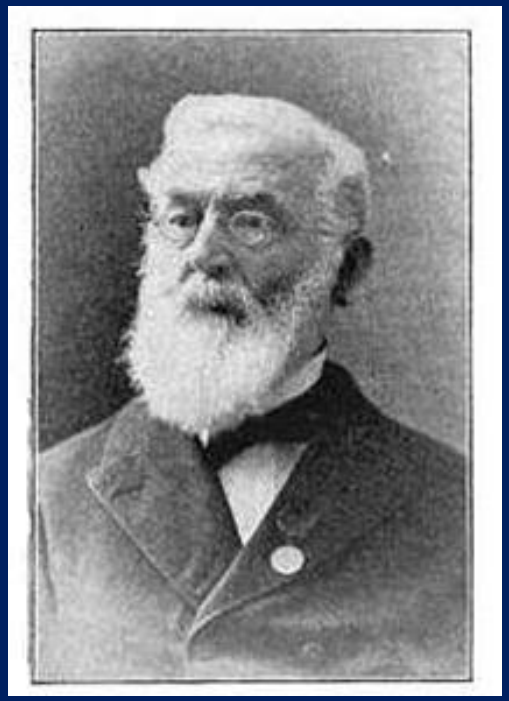
Geosynclines

- In geology, **geosyncline** is a term still occasionally used for a subsiding linear trough that was caused by the accumulation of sedimentary rock strata deposited in a basin and subsequently compressed, deformed, and uplifted into a mountain range, with attendant volcanism and plutonism.
- The filling of a geosyncline with tons of sediment is accompanied in the late stages of deposition by folding, crumpling, and faulting of the deposits.
- Intrusion of crystalline igneous rock and regional uplift along the axis of the trough generally complete the history of a particular geosyncline. It is then transformed into a belt of folded mountains.
- Thick volcanic sequences, together with greywackes (sandstones rich in rock fragments with a muddy matrix), cherts, and various sediments reflecting deep water deposition or processes, are deposited in *eugeosynclines*, the outer deep water segment of geosynclines.

Geosynclines

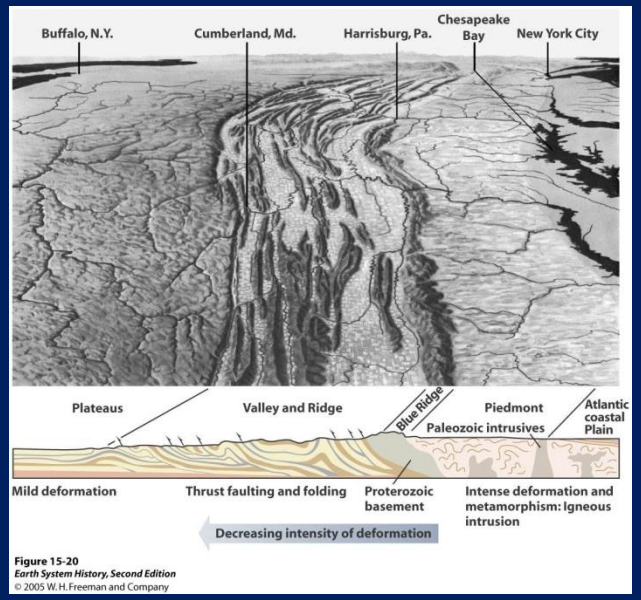
- Geosynclines are divided into *miogeosynclines* and *eugeosynclines*, depending on the types of discernible rock strata of the mountain system.
- A miogeosyncline develops along a passive margin of a continent and is composed of sediments with limestones, sandstones and shales. The occurrences of limestones and well-sorted quartz sandstones indicate a shallow-water formation.
- An eugeosyncline consists of rocks from deep marine environments. Eugeosynclinal rocks include thick sequences of greywackes, cherts,slates, tuffs and submarine lavas. The eugeosynclinal deposits are typically more deformed, metamorphosed, and intruded by small to large igneous plutons. Eugeosynclines often contain flysch typical of a continental-continental convergent boundary

Mountain-Building and the Geosyncline Theory

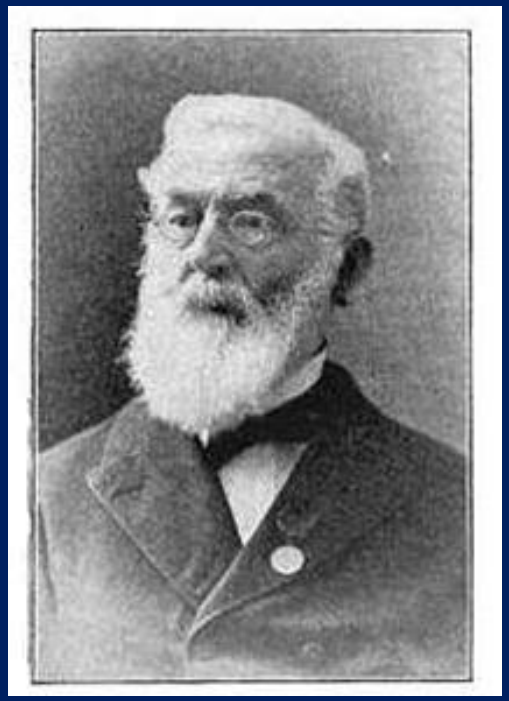


James Hall (1811-1898)
New York State Geologist
Paleontologist and Geologist

Hall noted that deformed (folded and faulted) Paleozoic strata in the Appalachians are 10 times the thickness of undeformed Paleozoic strata in the Mississippi valley. He proposed that the great sediment load in the Appalachians region caused crustal failure and downwarp. This warping caused the sedimentary layers to be deformed.

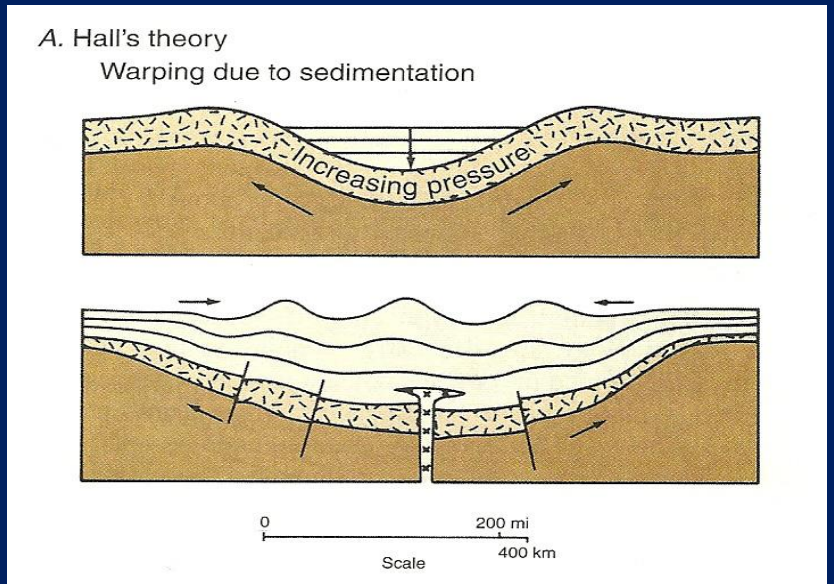


Mountain-Building and the Geosyncline Theory



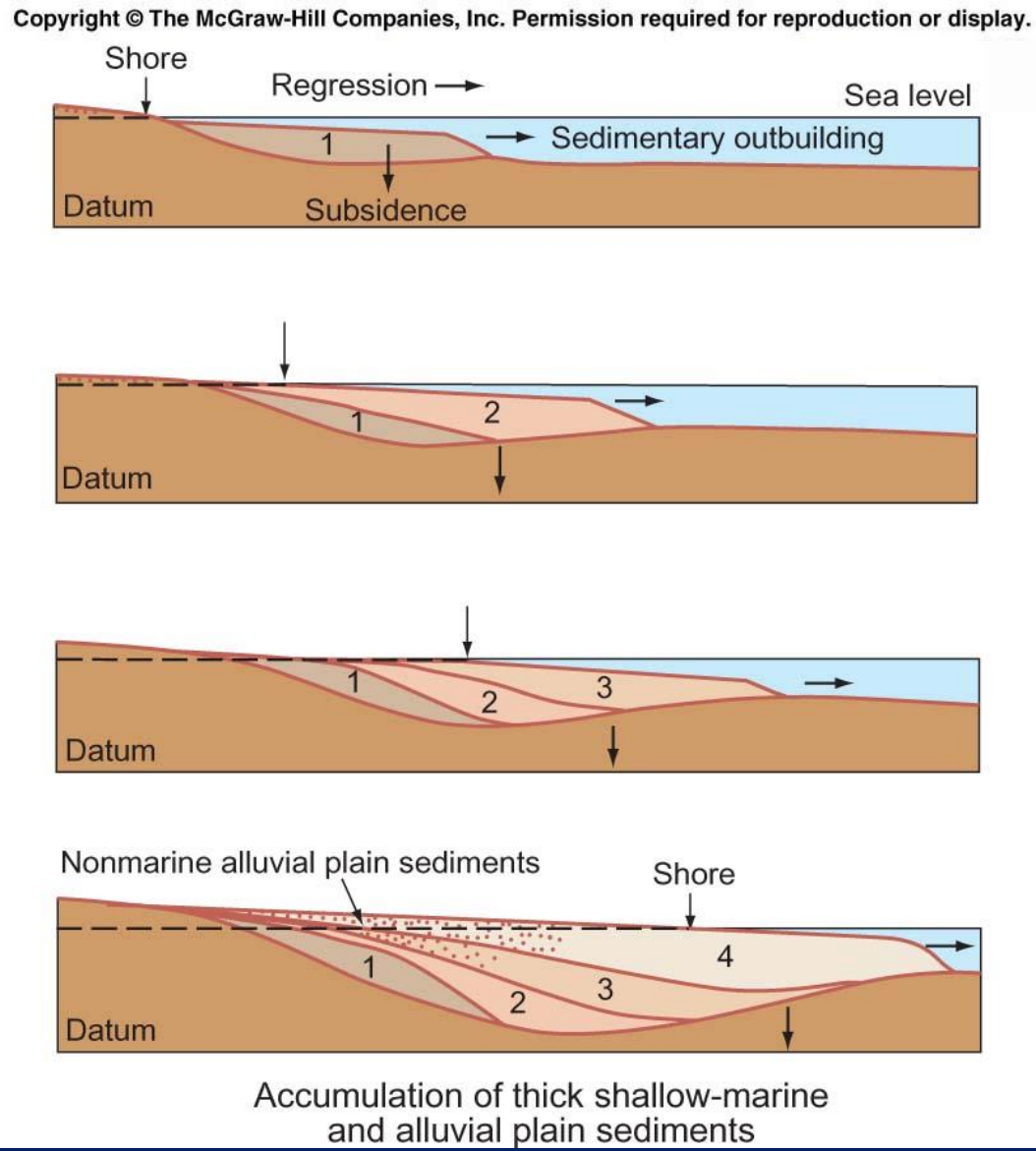
James Hall (1811-1898)
New York State Geologist
Paleontologist and Geologist

In seeking an explanation for the deformed nature of strata in mountain belts, Hall noted that the stratigraphic units thickened considerably from the cratons to the mountain belts.
He suggested that the weight of the over-thickened trough of sediments caused the crust to depress and eventually crumple.



Regional Crustal Subsidence due to local sediment loading

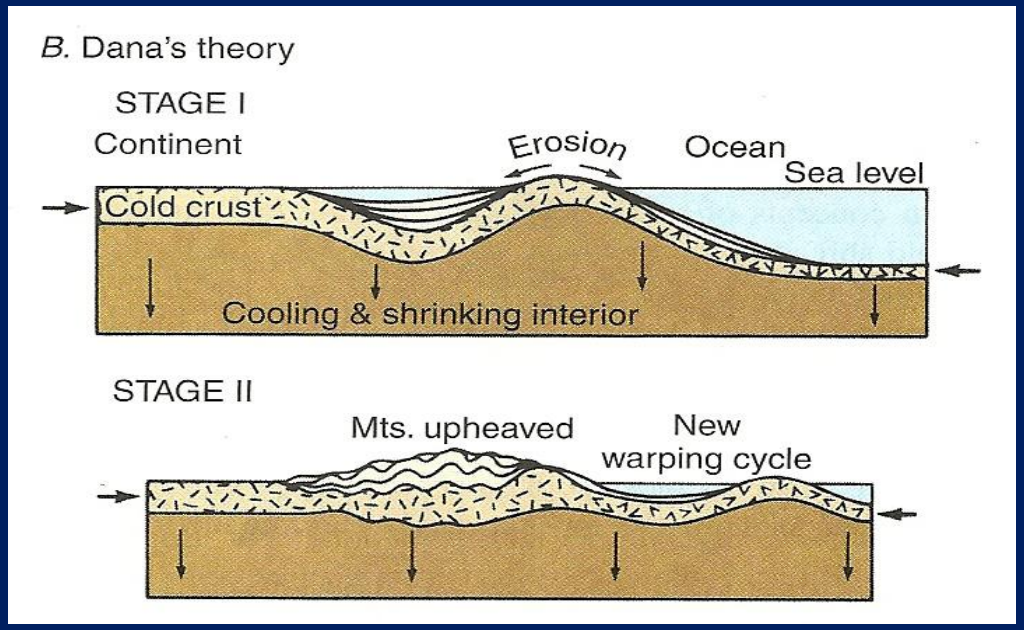
Sediments delivered by major river systems eventually deposit a non-negligible load on the crust, resulting in slight deformation (subsidence) and opens accomodation space for further sediment loading. (positive feedback).



Mountain-Building and the Geosyncline Theory

JD Dana (1813-1895)
Mineralogist, Volcanologist and Geologist

Had a similar idea to Hall's, but suggested that the over-thickened trough of sediment, which he termed a "geosyncline", was the result, not the cause of downwarping of the continent at their margins. He believed the warping resulted from cooling and contraction of the earth.



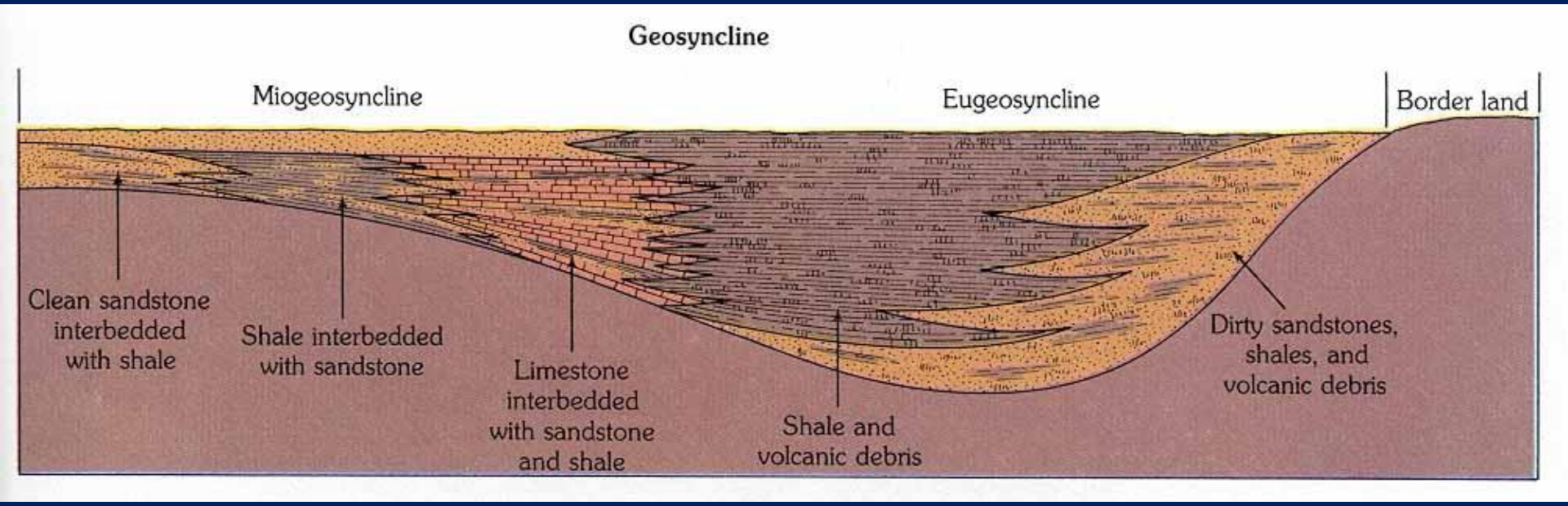
The concept (idea) of a geosyncline

- In the early history of stratigraphy, in the 19th century, it was realized that stratigraphic successions in mountain ranges were often much thicker, or of much deeper water facies, than equivalent successions on undeformed continental cratons.
- This gave rise to the idea that mountain belts originated in extended linear subsiding troughs, which were termed **geosynclines**.

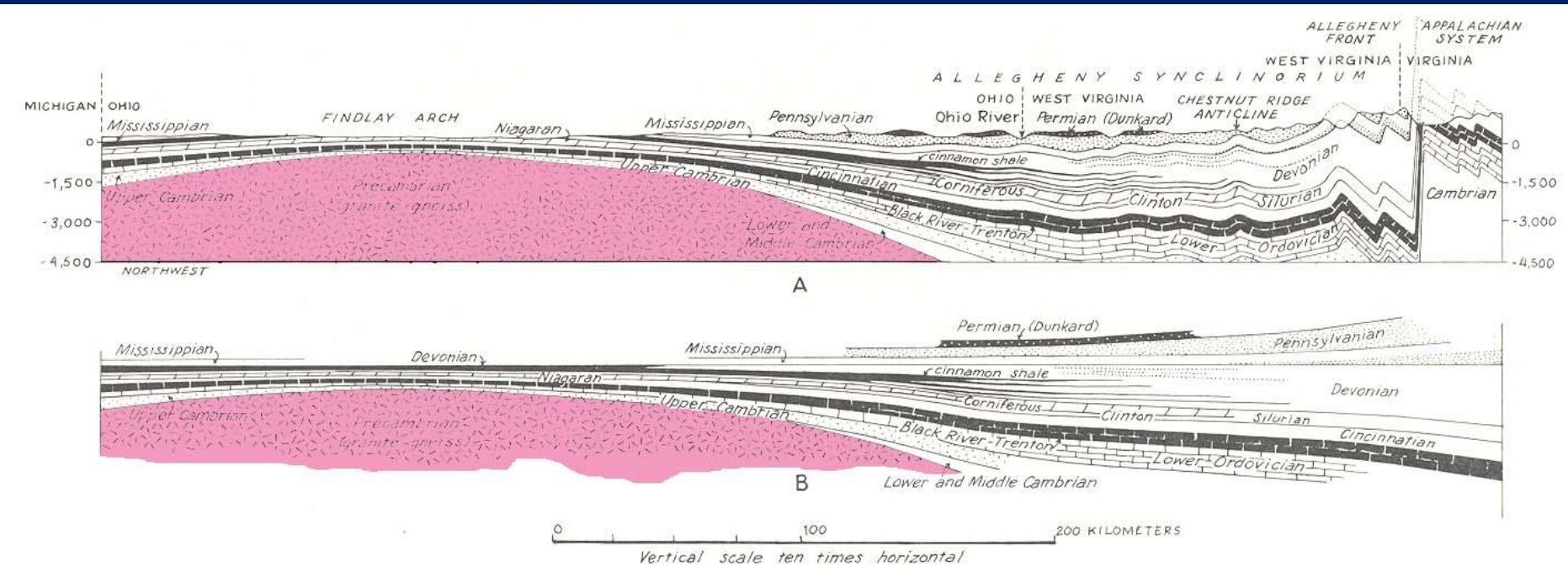
The concept (idea) of a geosyncline

- Geosyncline is a long, relatively narrow and deep trough in the earth's crust.
- It may extend for tens or hundreds of kilometers.
- It is found on the bottom of marine basins and is usually bounded by faults and filled with thick strata of sedimentary and volcanic rock.
- As a result of intensive tectonic deformations over a long period of time it is transformed into a complex folded formation that is part of a mountain structure.

Geosynclinal Theory



Geosynclinal Theory



Top: Structure and sediment thickness from Ohio to New York

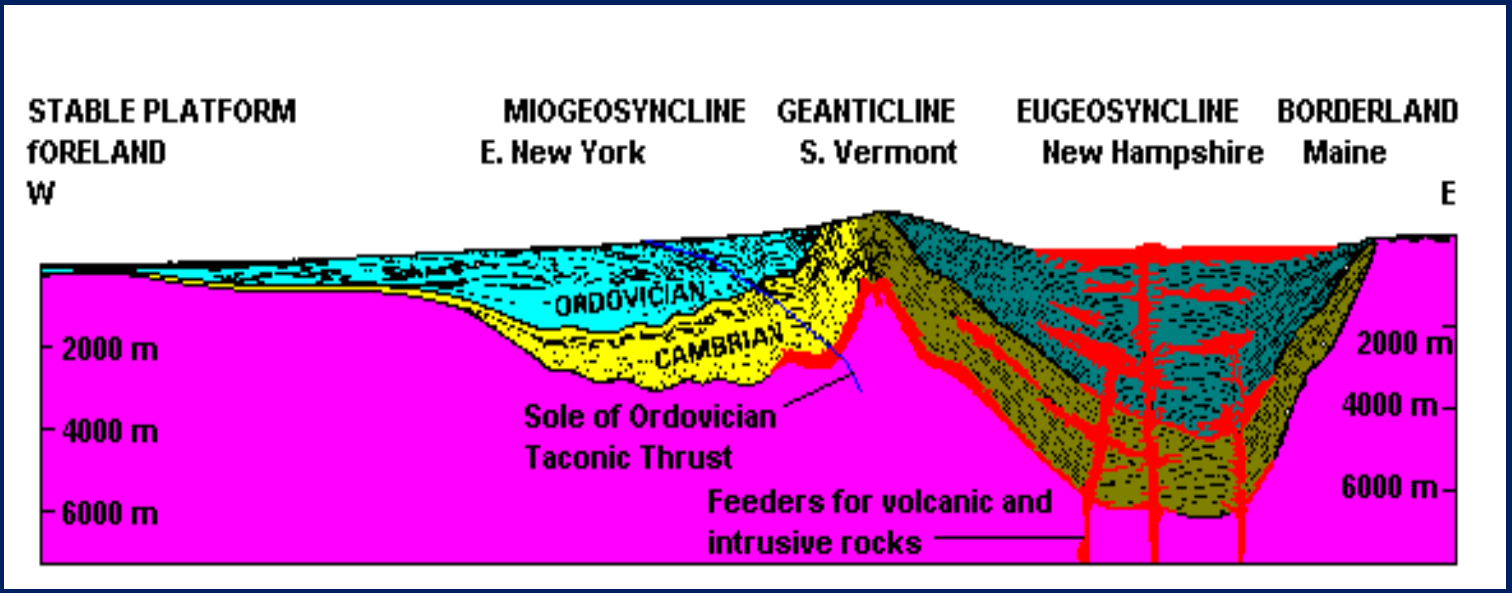
Bottom: Same traverse with structure eliminated

The Geosyncline

- The geosynclines had a paired structure of parallel troughs.
- Miogeosyncline (meaning 'moderate geosyncline') contained mainly non-volcanic sedimentary successions.
- Eugeosyncline (meaning 'good geosyncline') contained volcanics and thick successions of immature sediments like wackes.
- The two were separated with a geanticline.

The Geosyncline

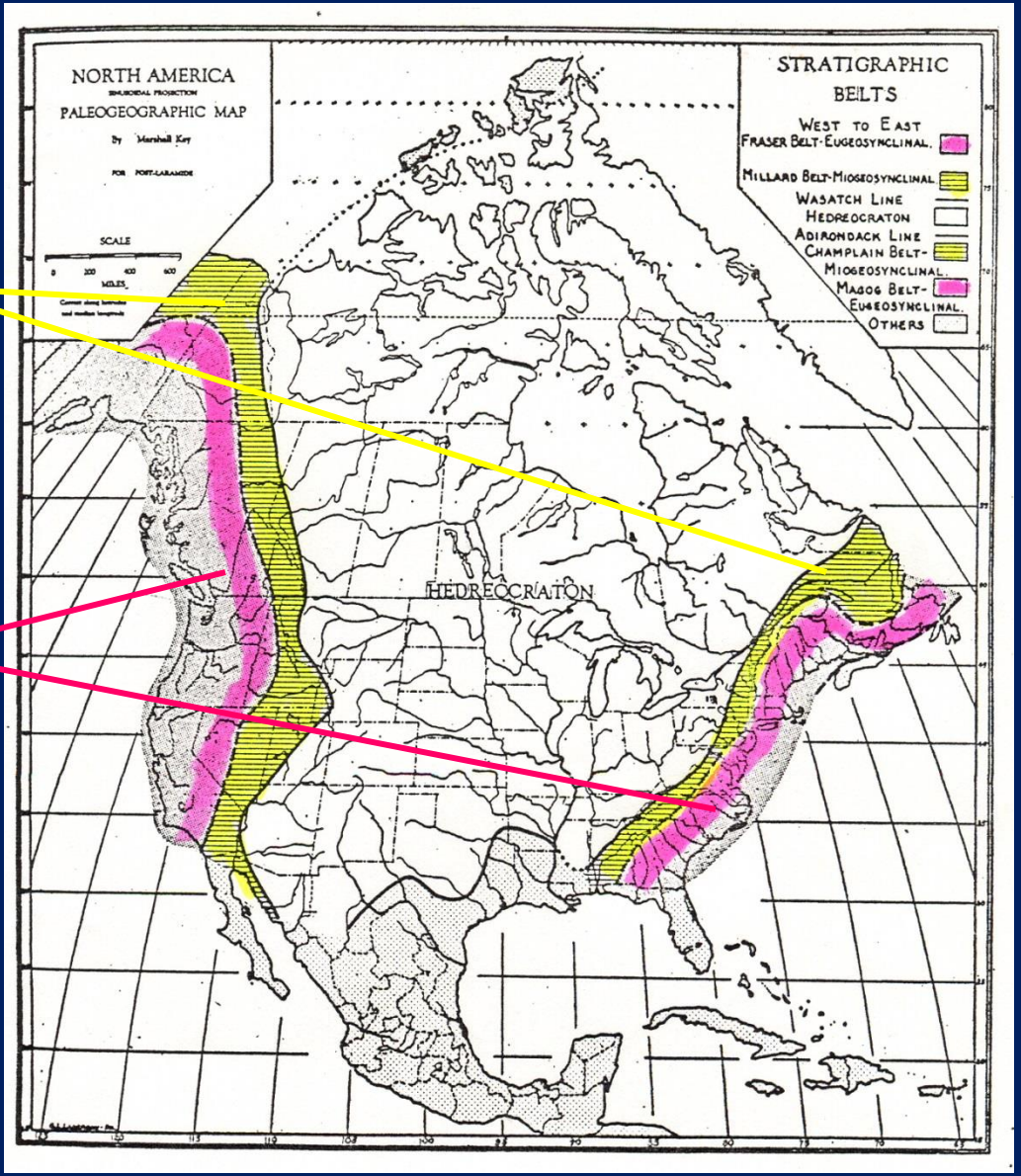
- Miogeosyncline contained mainly non-volcanic sedimentary successions mostly shallow-water sandstones and limestones and deeper water pelagic sediments.
- Eugeosyncline contained mixed successions of mafic volcanic rocks and deep sediments (shale and chert).
- The two were separated with a geanticline.



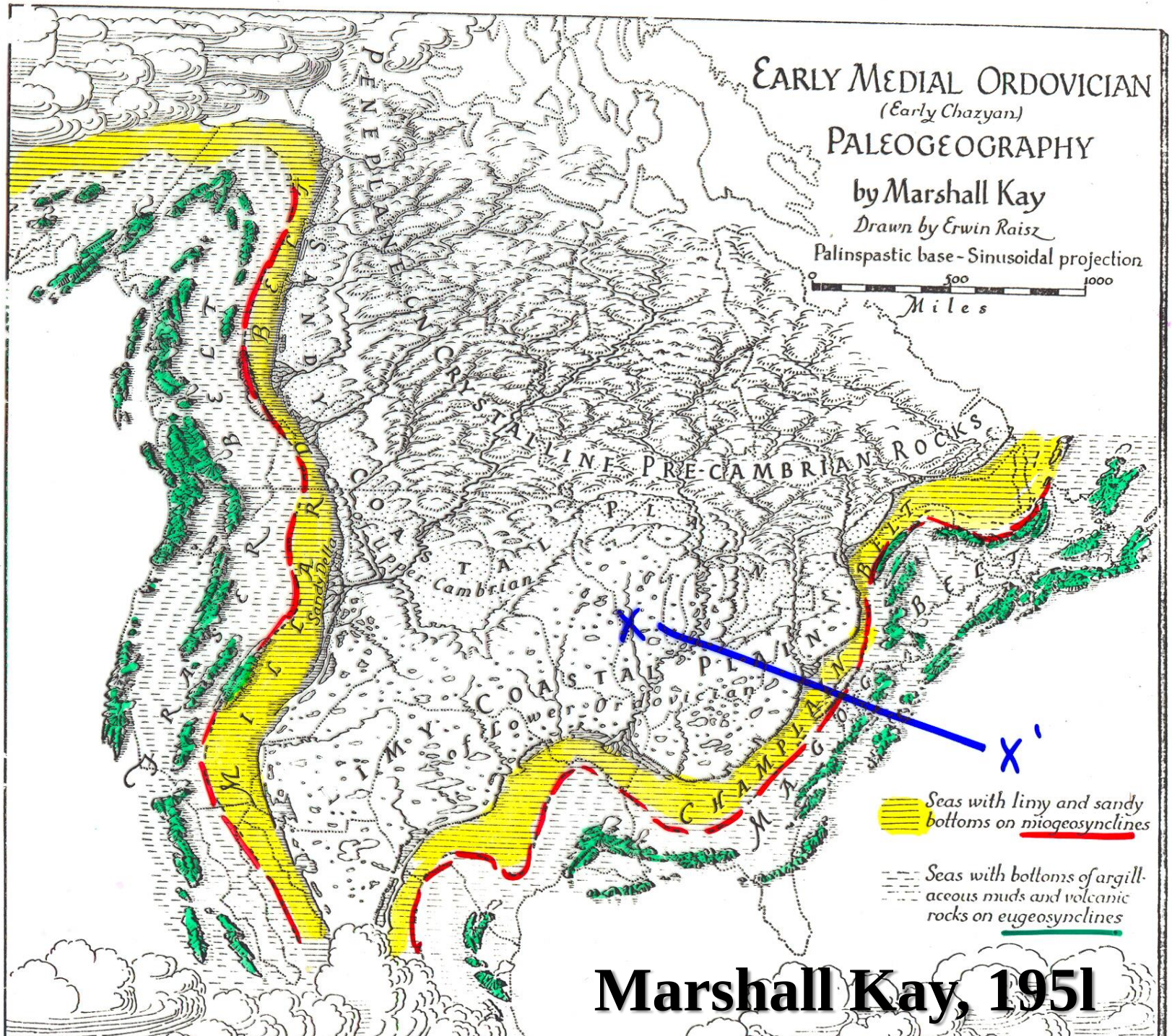
North American geosynclines (Kay, 1947)

MIOGEOSYNCLINES

EUGEOSYNCLINES

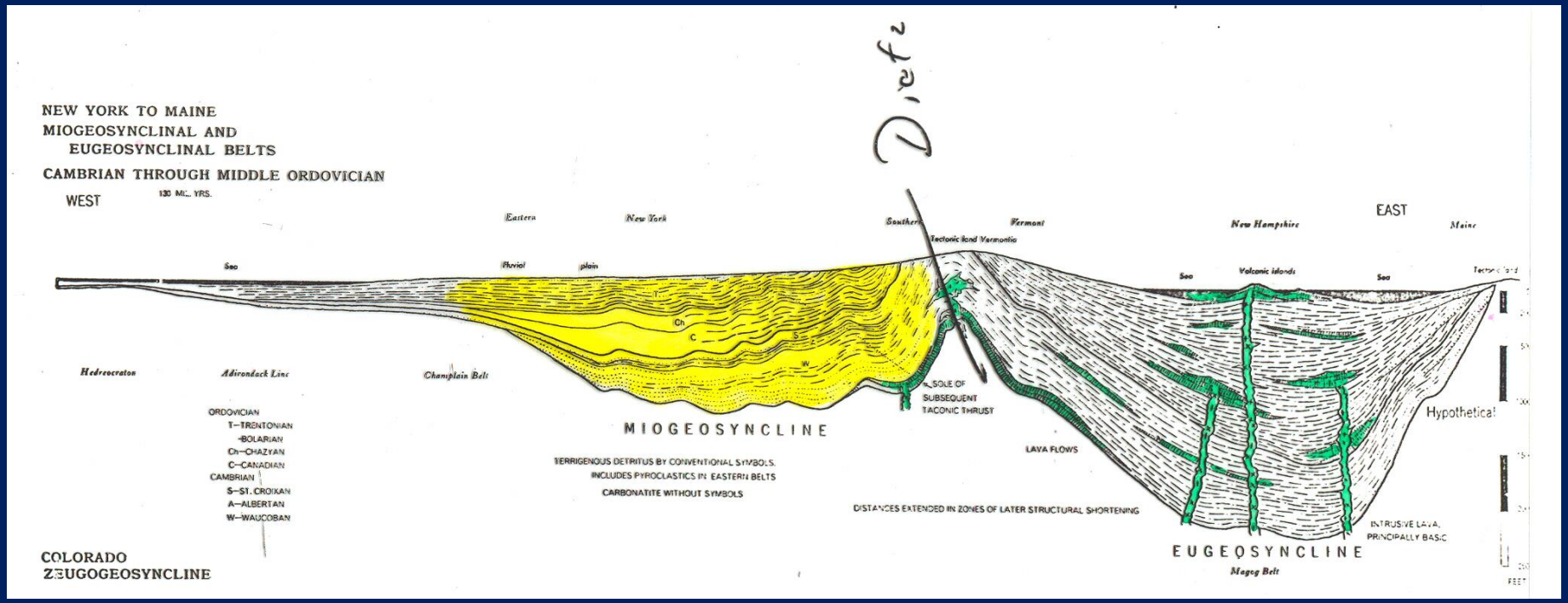


Marshall Kay, 195l

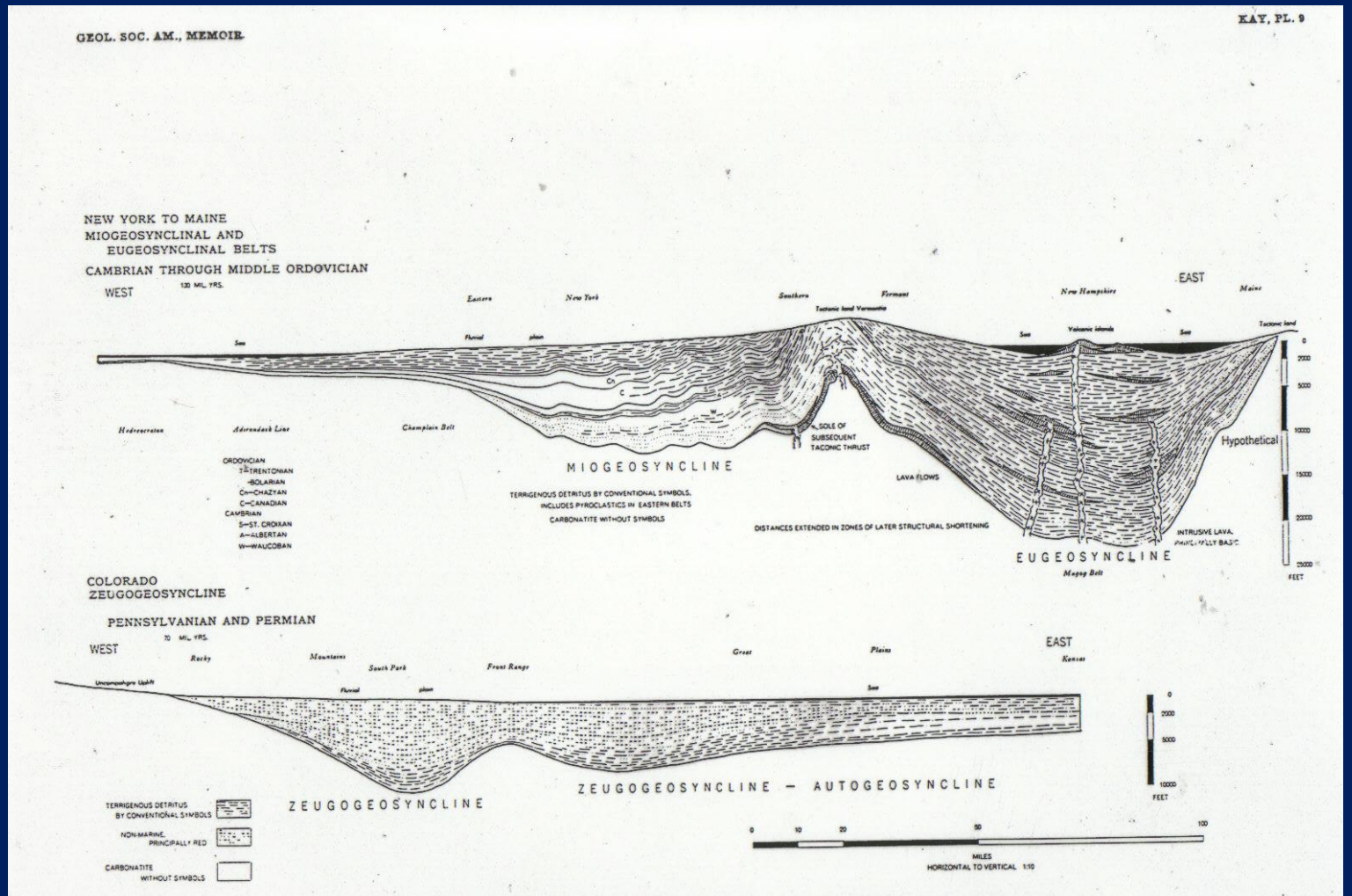


Marshall Kay, 1951

Kay's Ordovician reconstruction of the Appalachian geosyncline

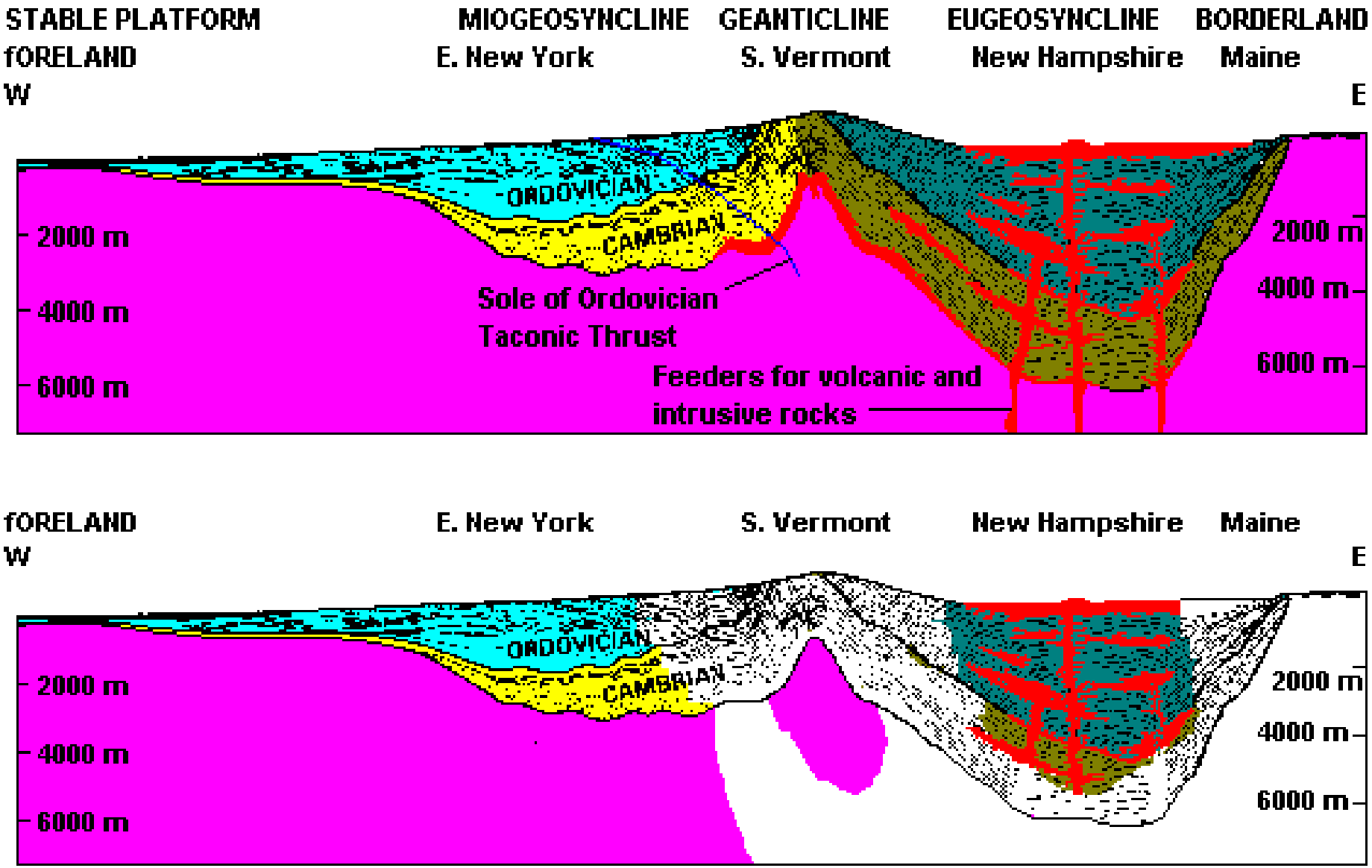


Kay's Ordovician reconstruction of the Appalachian geosyncline



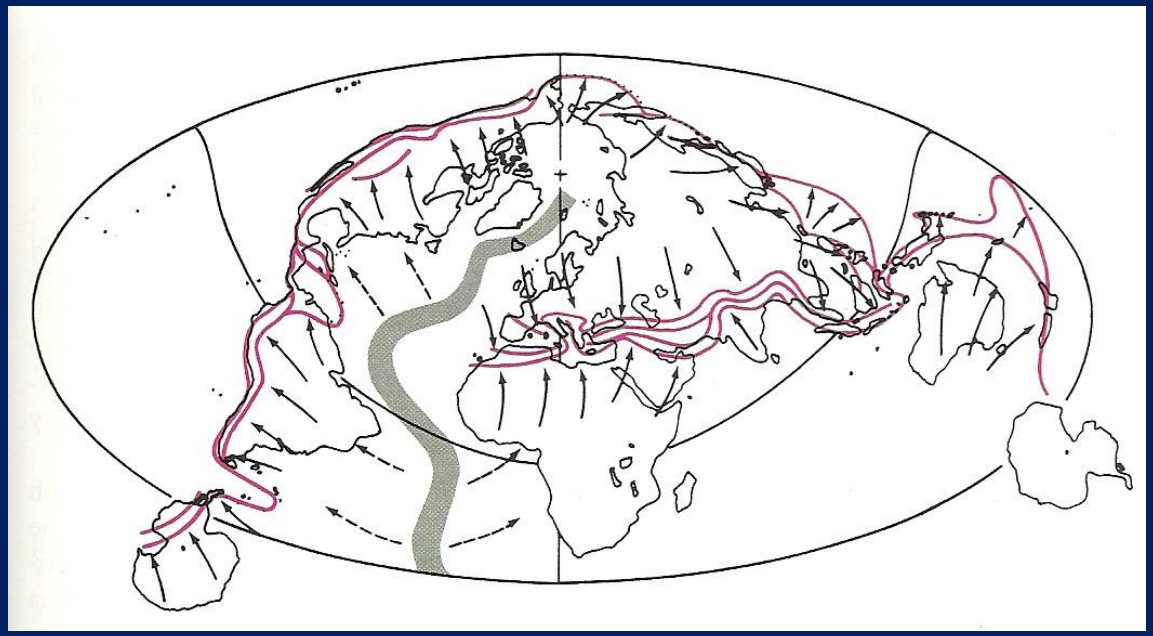
RESTORED SECTIONS OF CAMBRIAN AND ORDOVICIAN IN MIOGEOSYNCLINE AND EUGEOSYNCLINE, NEW YORK TO MAINE, AND OF PENNSYLVANIAN AND PERMIAN IN ZEUGOGEOSYNCLINES IN COLORADO

Geosynclines: the original concept (idea)



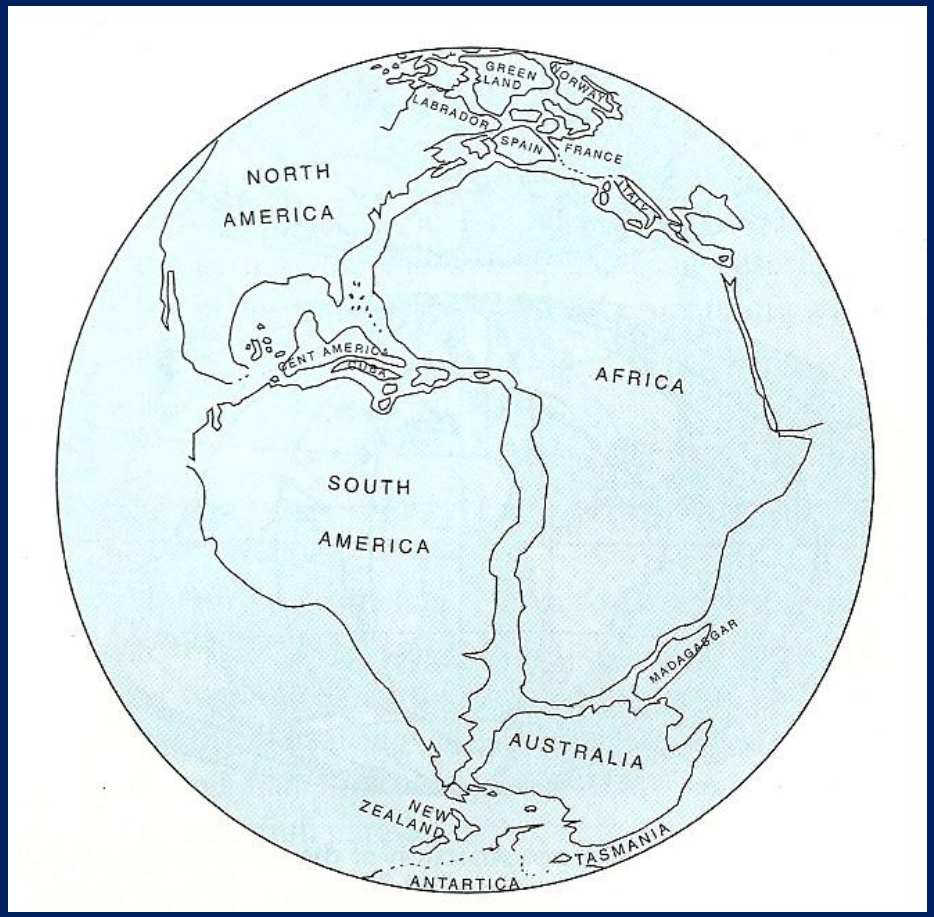
Continental Drift and Mountains

- The discovery of radioactive heating of the earth in the early 1900's made mountain building by horizontal compression due to a contracting Earth impossible.
- Scientists started to speculate that may be, just may be, the continents could move horizontally – DRIFT.



1908 – American F.B. Taylor suggested that drifting of the continents was responsible for the great Cenozoic mountain belts. Speculated that capture of the moon was responsible.

Pre-Drift Continental Reconstruction



1912 – Another American H. Baker postulate the first reconstruction of what we now call the Pangea supercontinent.

He speculated that the moon was ripped from Earth to form the Pacific basin prompting the continents to drift toward the void.

Alfred Wegener
Father of the Hypothesis of Continental Drift

Alfred Wegener
1880-1930

1915 – The Origin of Continents and Oceans (3rd edition, 1922)

Meteorologist by training

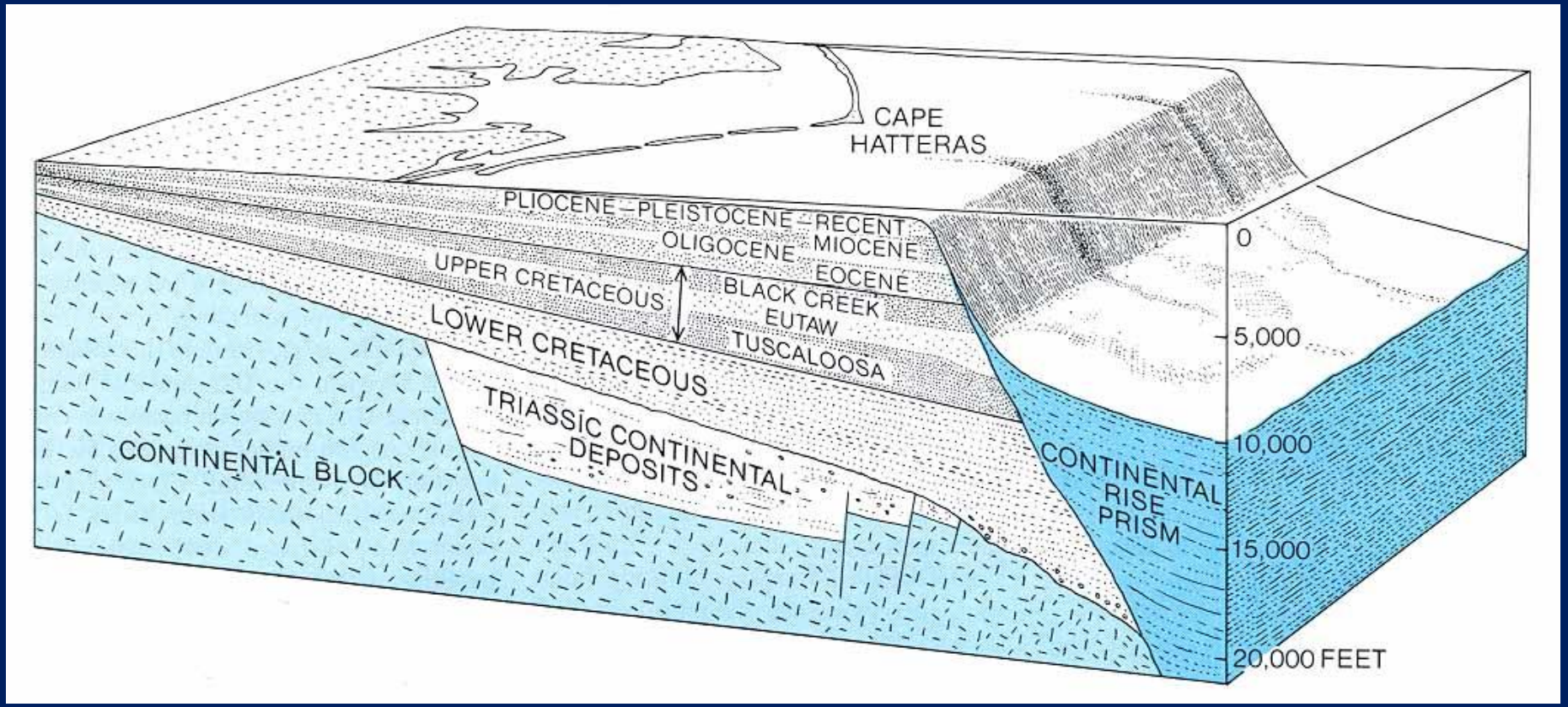
Introduced the hypothesis of Continental Drift

Postulated the existence of the supercontinent he named Pangea

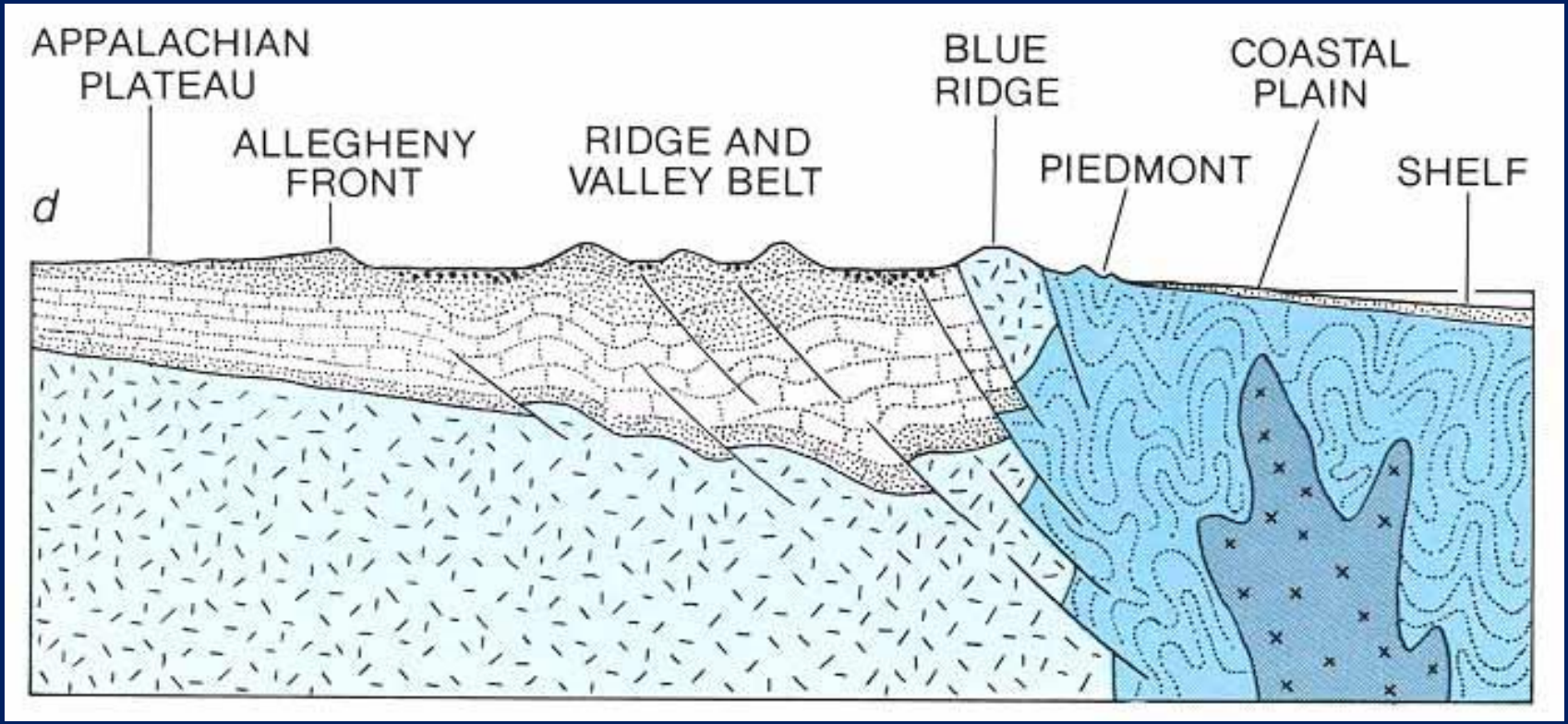
Evidence:

- Fit of the continents
- Fossil record
- Similar geologic structures
- Similar paleoclimates

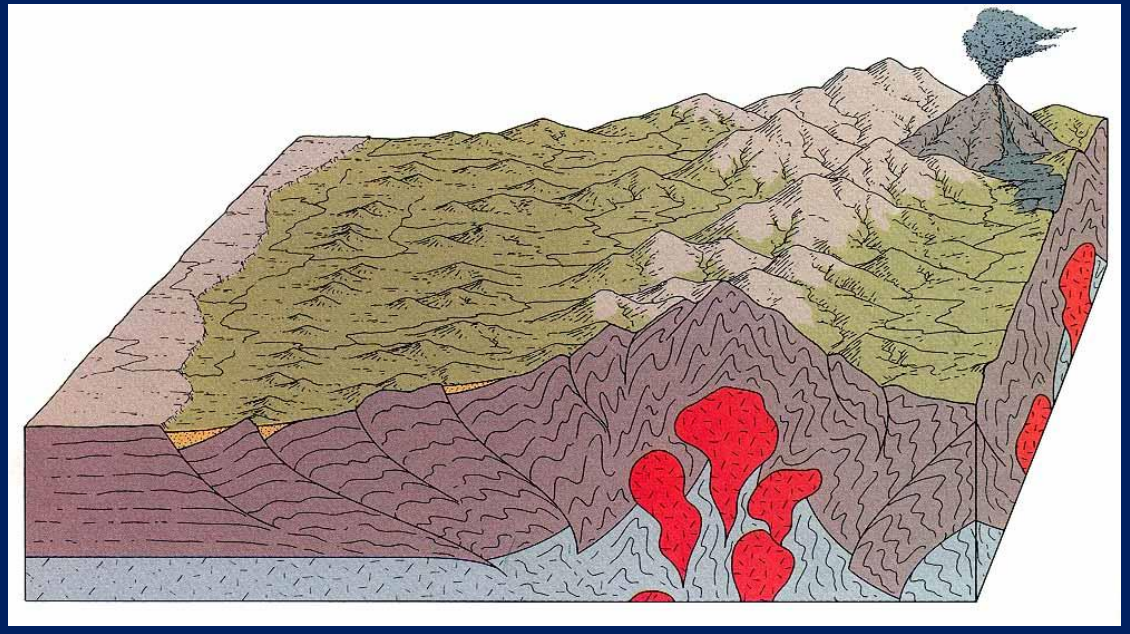
Geosynclinal Theory

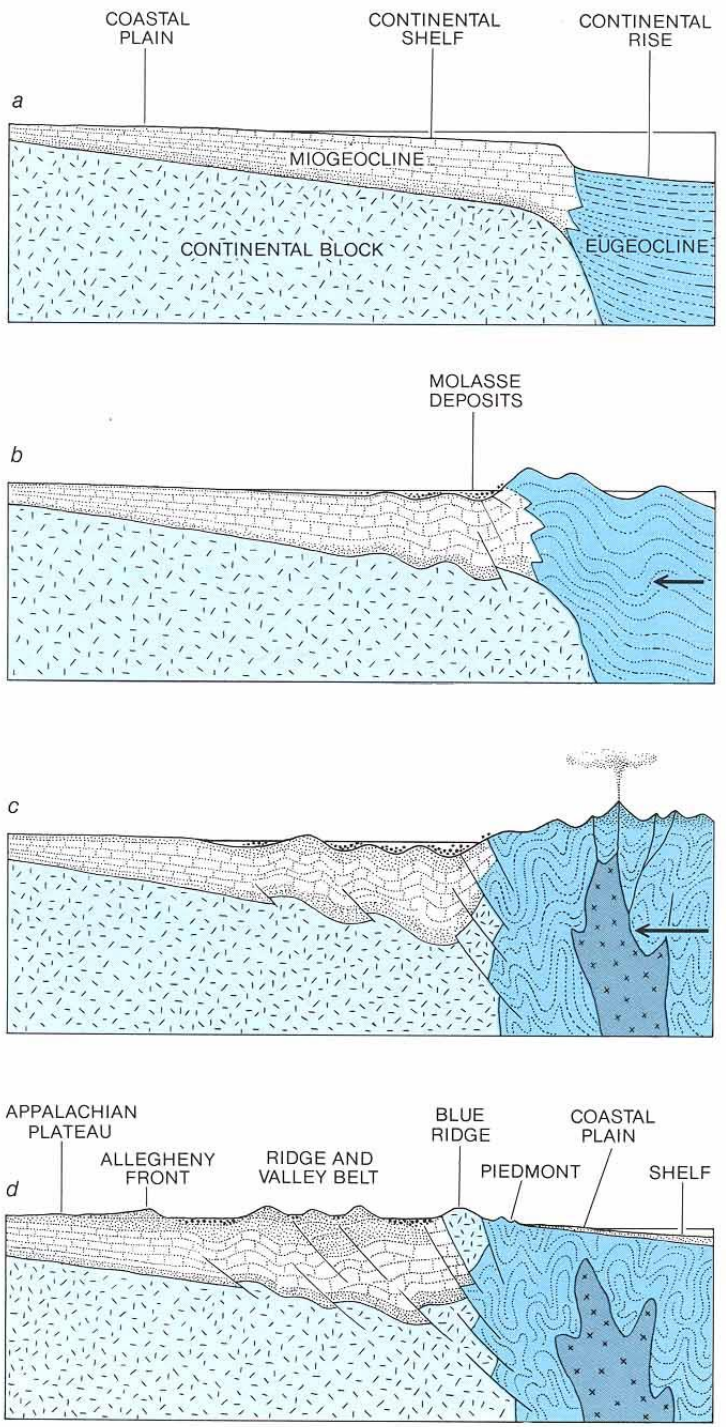


Geosynclinal Theory

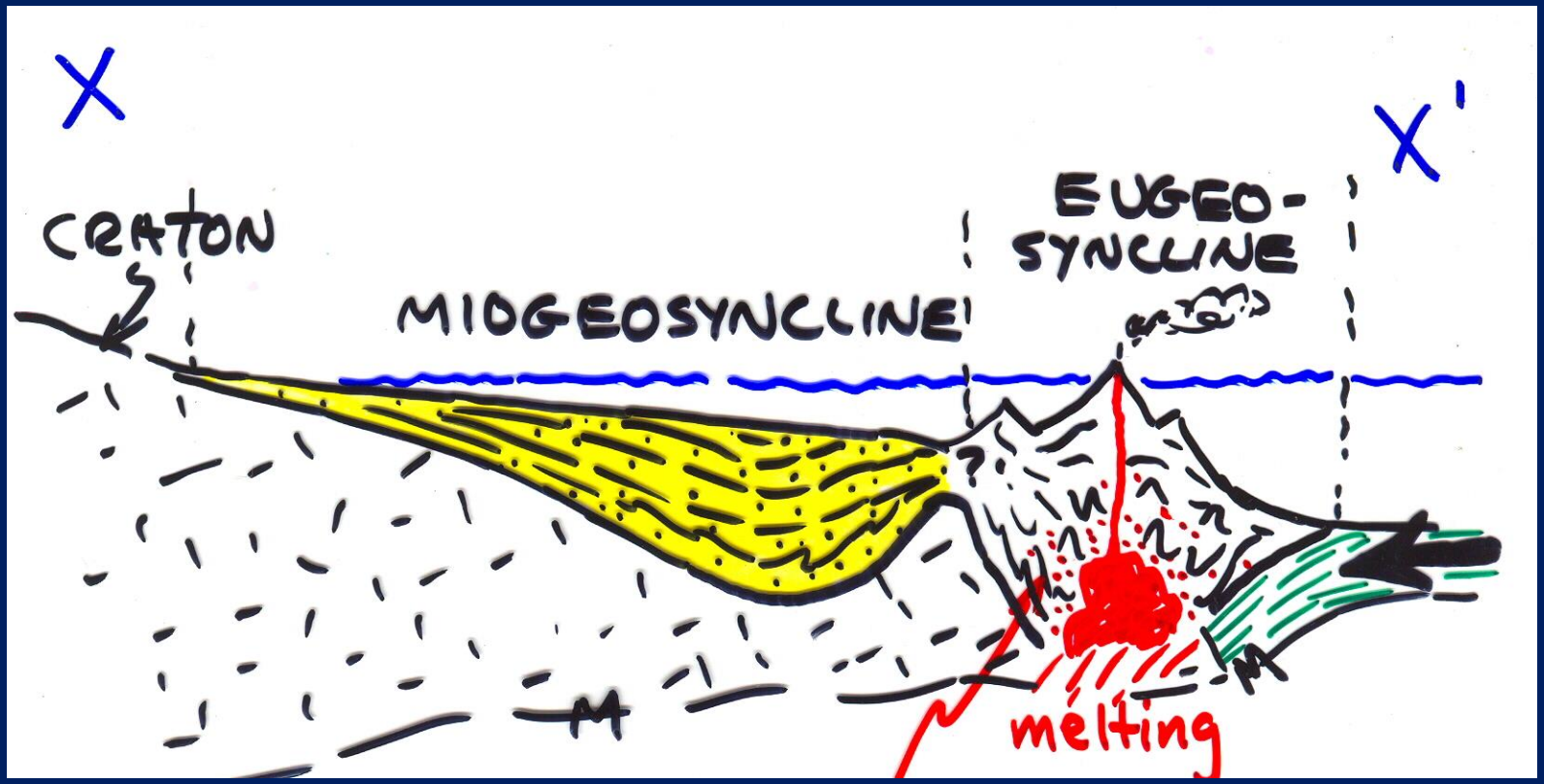


Geosynclinal Theory





An early idea: oceanic "push" leads to shortening, thickening, and melting of the eugeosyncline

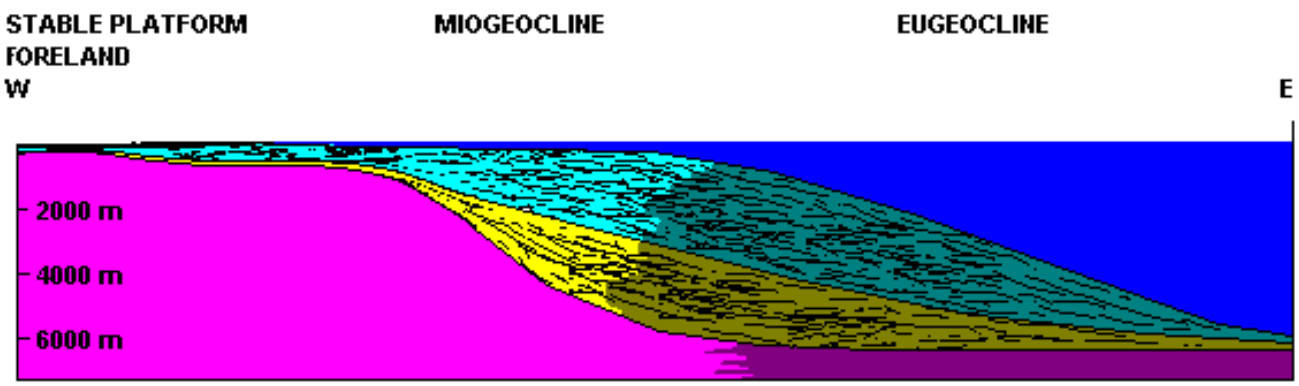


Geosynclines

Robert S. Dietz's new interpretation in the early 1960's

In the 1960s, as plate tectonics was just getting going, Robert Deitz went looking for modern geosynclines. He suggested that what we now call passive margins, like the eastern seaboard of N America and the Gulf of Mexico, were modern analogues for geosynclines. He suggested that the median geanticlines were absent, and that the geosynclines really aren't synclines but wedge-shaped accumulations of strata.

Hence he removed the 'syn' from both terms, defining miogeocline and eugeocline.

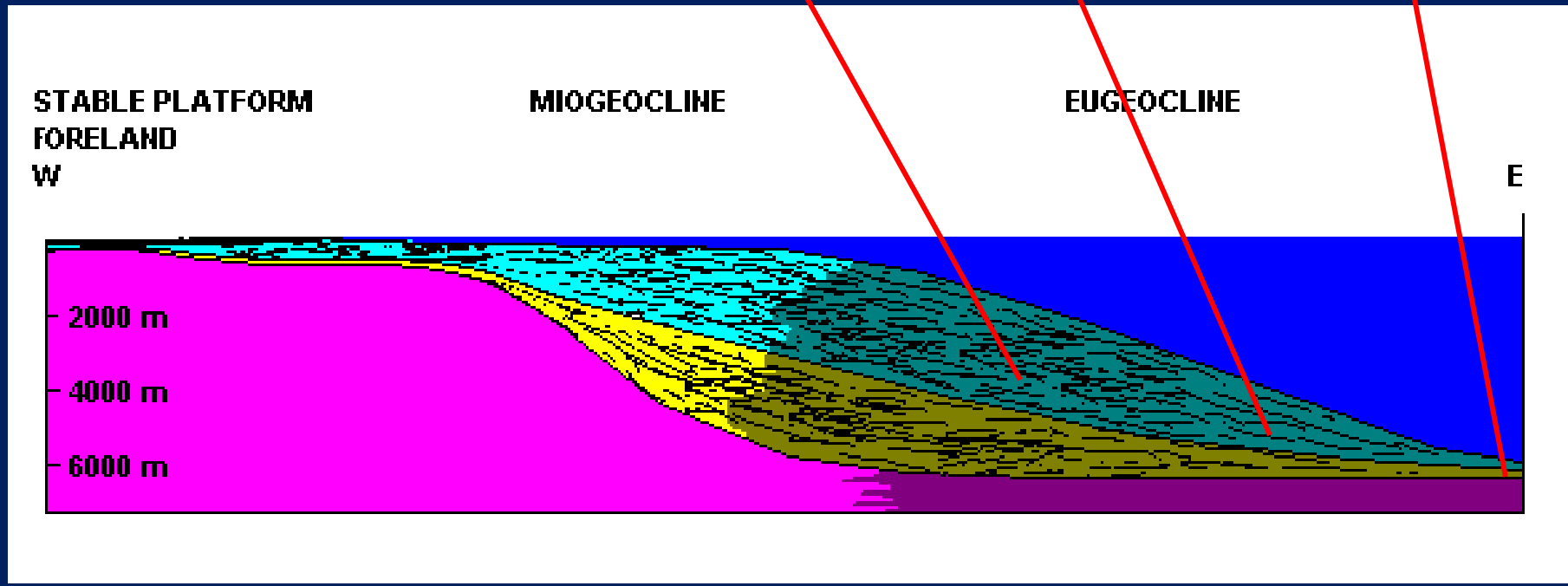


www.uwgb.edu/dutchs/platetec/ geosync.htm

GEOSYNCLINES — Robert S. Dietz's new interpretation in the early 1960's:

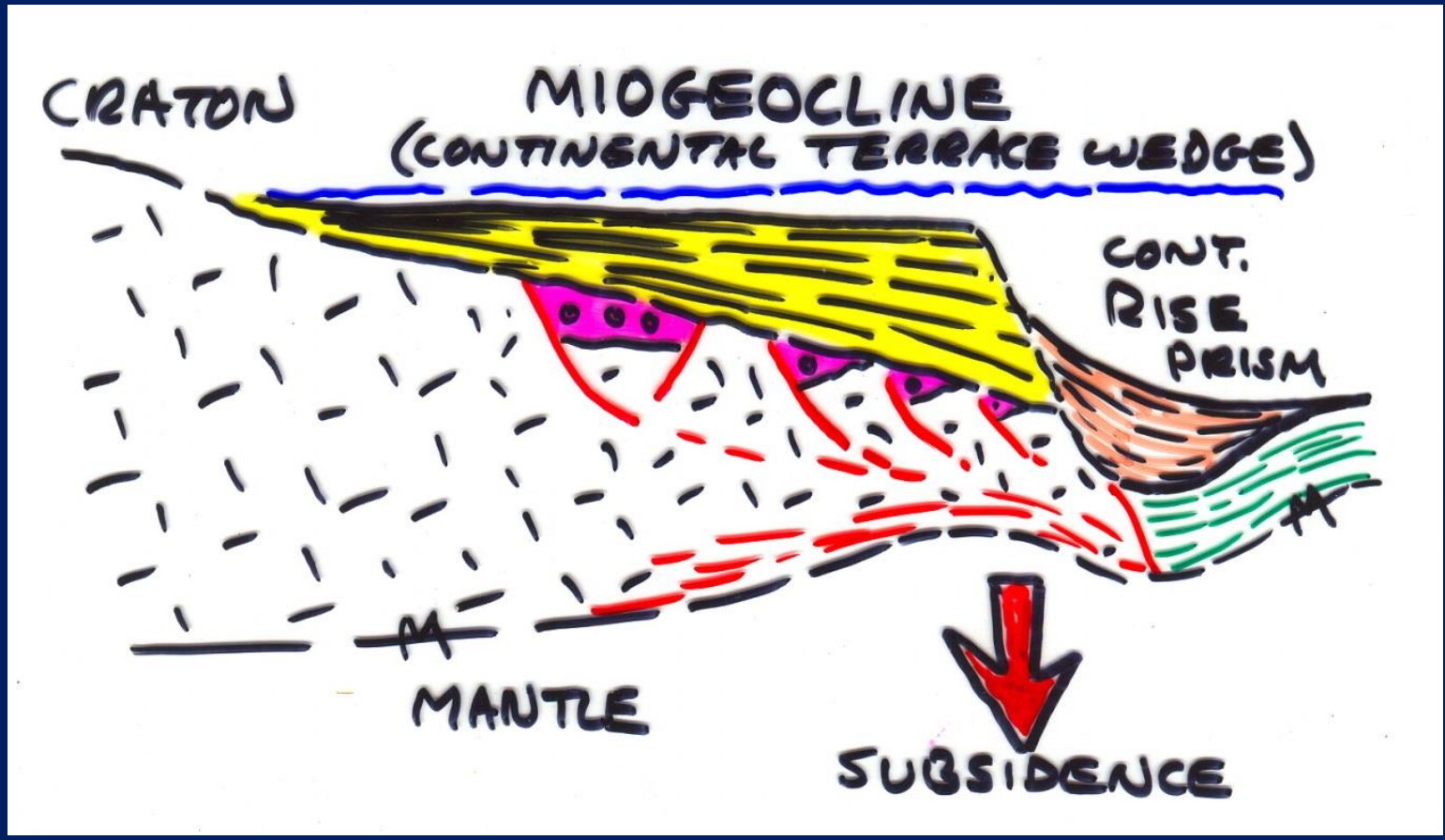
miogeosynclines = continental shelf, upper slope;

eugeosynclines = lower slope, rise, deep sea floor

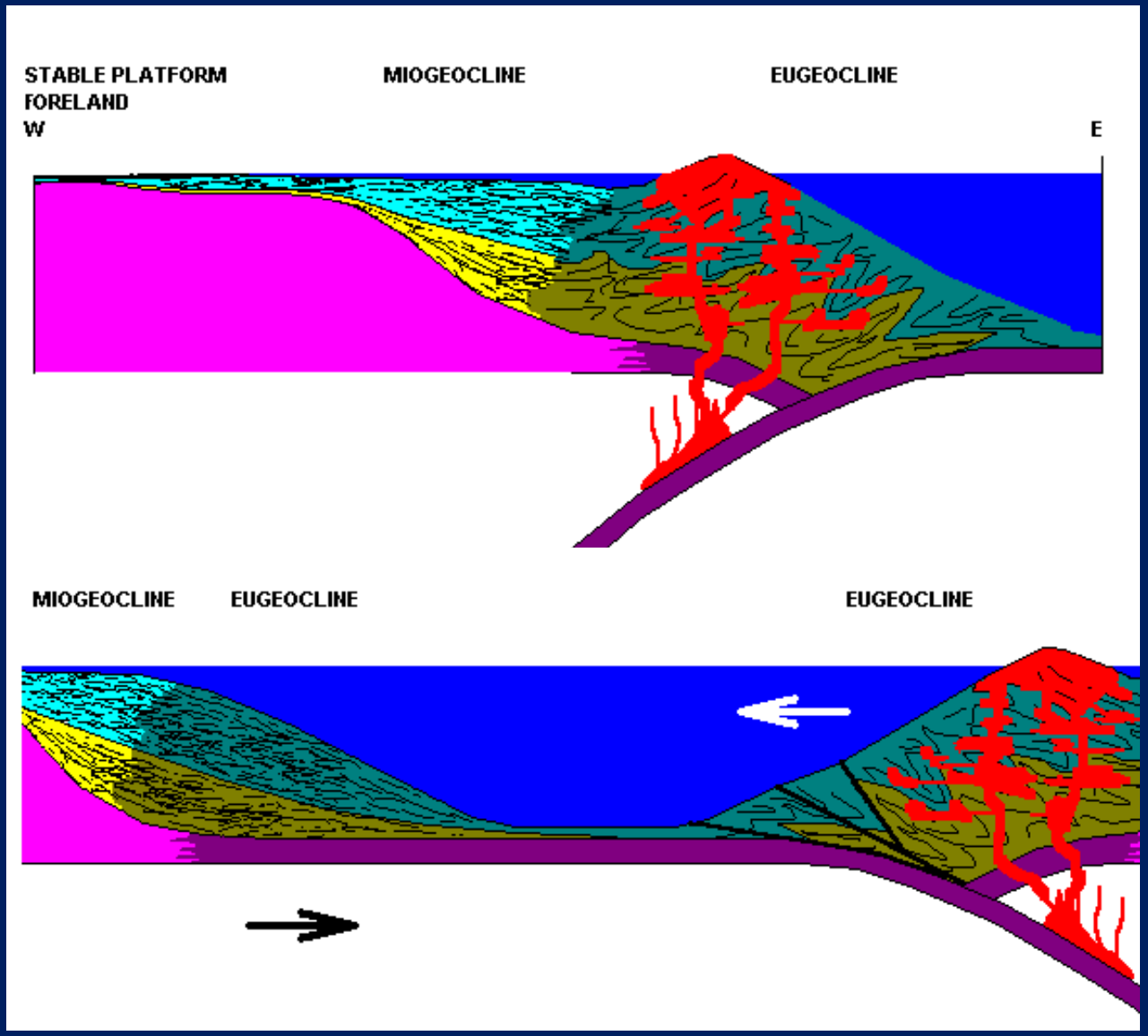


www.uwgb.edu/dutchs/platetec/ geosync.htm

Robert Dietz refined the idea of geosynclines at first (1950s)

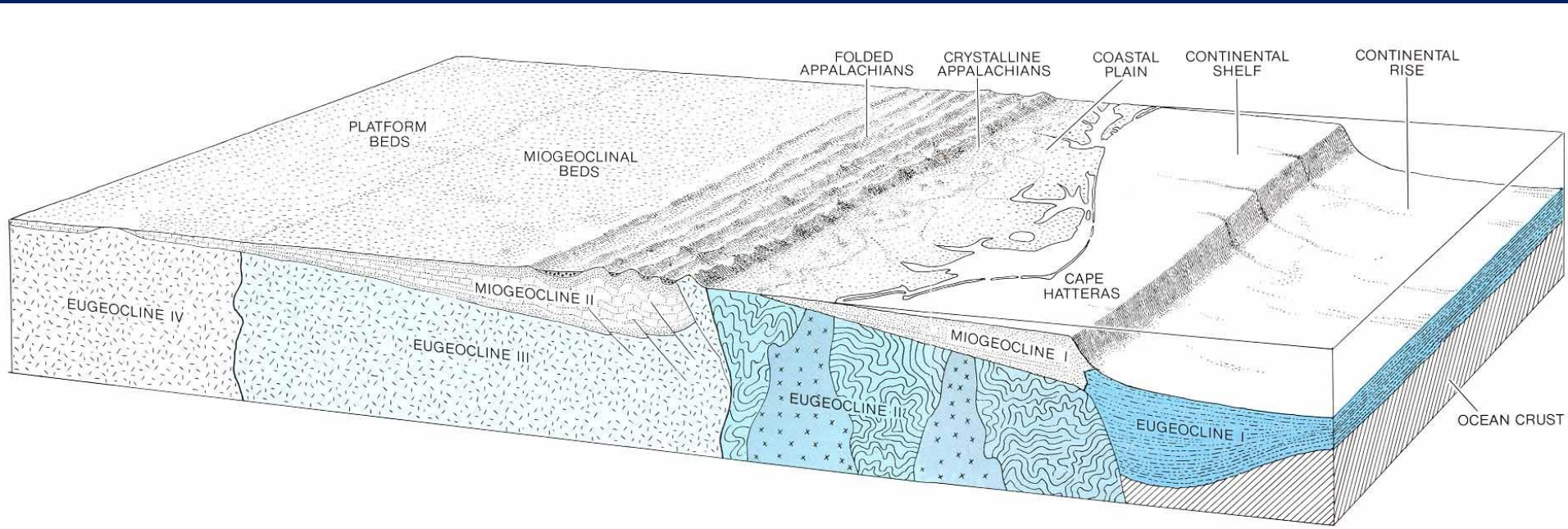


- In the 1970's geologists began to realize there was another way to make a geosyncline; form the two parts separately and join them later by plate collisions.
- Much of the Appalachian mio-eugeosyncline pair actually formed this way.



If subduction begins off such a continental margin, volcanic rocks, mixed with sediment eroded from the volcanic arc, will be added to the eugeosynclinal part of the embryonic mountain chain.

Geosynclinal Theory



Geosynclines

Summary

- The idea was that troughs developed adjacent to continents or between continents; the cause of the initial subsidence was never determined
- Troughs began to fill with sediment but continued to subside
  - Troughs were subdivided into two parts
    - Nearer the continent was the miogeosyncline which had limey sediments and clean quartz sands; not much clay or volcanics
    - Farther from the continent was the eugeosyncline which had volcanics and clay-rich sands
- Evenutually, the trough became unstable, was folded, intruded, and uplifted
  - Mechanism was not explained
  - Sediments depressed to great depth where temperatures increased and become unstable—The earth burped
  - Clark and Stearn (1968) and others argued that horizontal compression was important although they never had a good source
- Tends to a model for continental accretion that adds younger rocks to the margins of continents

How plate tectonics killed the geosyncline model

The geosynclinal theory envisioned primarily vertical motions (downwarp, upwarp) with only minor horizontal motions due to contraction. Almost no serious scientist through the early twentieth century considered horizontal motions of the Earth's crust. The continents were formed and remained in place and for endless eons they were the site of the continuous struggle between erosion (destruction) and upheaval (construction).

The discovery of radioactivity cast doubt on Kelvin's cooling Earth model.

How plate tectonics killed the geosyncline model

- Subsequently, it was realized that passive margins were too poor in mafic igneous rocks to be equivalents of eugeo-anything.
- Rocks formerly interpreted as eugeosynclinal were re-interpreted as products of subduction - trenches, forearc basins, and island arcs, transported much longer distances than ever envisaged by the pioneers of geosyncline theory.