25. Mountain Ranges and the Construction of Continents

Mountain Building

Although the Earth is 4.6 billion years old, we see that many mountain ranges on Earth are far younger, having formed within the last _______________________ years.

These young mountain ranges typically occur near to active plate tectonic boundaries, particularly ______________________ (i.e., at ________________________).

What is the collective term used to describe all the processes responsible for the creation of mountains? ___________________. When this happens, a region is said to have undergone an ________________.

Because of the great forces associated with tectonic plates colliding, one of the most important factors in orogenesis is ______________________. This stress causes mountain ranges to be extremely internally deformed, meaning the rocks are intensely _______________ and _______________.

Subduction zones are also commonly associated with volcanoes, so many mountain ranges also have a core of___________________.

The mountains themselves are often constructed out of the products of volcanic eruptions, such as _______________. As a result of the large amount of deformation of the mountains, the deep roots of the mountains typically contain a lot of _________________.

What are some examples of young and active mountain ranges along convergent plate boundaries?

(1) ___________________ (includes the __________ and ________________)

(2) ___________________

(3) Also the island nations of Japan, Phillipines, and Indonesia.

What are two examples of ancient mountain ranges that indicate the locations of ancient convergent plate boundaries?

(1) ___________________

(2) ___________________

Subduction Zones

The two types of convergent plate boundaries where subduction actively occurs are: ______________________ and ______________________.

What are the four typical component parts of any subduction zone?

(1) ___________________ (where the subduction begins)

(2) ___________________ (the region between the trench and the volcanoes)

(3) ___________________ (the line of volcanoes)
(4) __________________ (the side of the volcanic arc opposite the trench)

Where an ocean plate subducts beneath an ocean plate, the line of volcanoes on the upper plate is called an ________________ (e.g., ________________).

Where subduction occurs beneath a continental plate, the line of volcanoes on the continent is just called a ________________. (e.g., SW Alaska; ________________; ________________).

This type of plate boundary is often called an ____________________________________.

**Andean-type Margins**

All Andean-type margins start off as a ______________________.

The continental shelves or platforms of these margins contain sedimentary rocks such as:

_________________________           __________________           __________________

Eventually, the oceanic crust along the passive margin gets compressed and starts to subduct beneath the continent.

As the plate subducts, seafloor sediments are scraped off of the ocean plate, forming a zone of crumpled seafloor sediments next to the trench called an ____________________.

What occurs in-between the accretionary wedge and the volcanic arc? ________________

Sediments accumulate in this basin after being eroded off of the higher areas to either side of it, and are deposited under marine conditions.

Melting and magma production during subduction causes magma to rise up into the overriding plate and collect in magma chambers. If this magma cools and crystallizes inside the crust, it forms a body of igneous rock called a ________________.

The collection of many plutons right next to each other is called a ________________.

Uplift and erosion of batholiths is responsible for many mountains and high areas in the western United States, including:

_________________________ and ________________

Accretionary wedge and forearc basin sediments may get deformed and uplifted to the point that they form mountain ranges that rise above the ocean.

Examples: ________________________ (Pacific Northwest)

________________________________

The subduction zone that created the Sierra Nevada and the California Coast Range was related to the subduction of the ancient Farallon plate beneath North America. This subduction zone finally disappeared about 30 million years ago to be replaced by the San Andreas fault.
What part of this ancient subduction zone is represented by the central valley of California?

______________________________

**Continental Collisions**

What type of convergent plate boundary where mountains develop does not involve one of the plates being completely subducted? ___________________________

Such continental collision zones cause crustal rocks to be compressed, resulting in the development of folding and a type of low-angle reverse fault called a thrust fault.

What do we call such zones of deformation? ___________________________

The ancient join between the two continents is called a ________________.

Example of where this occurred: ___________________________

The Himalayas formed due the collision of India with Asia. How long ago did this collision start?

__________________________

Originally, India’s northern margin was a passive margin, containing a platform of marine sediments. As India began colliding with Asia, the marine sediments of this passive margin became deformed and got uplifted to form the mountains, which therefore contain a lot of deformed marine sedimentary rocks.

Because continental India was not able to subduct very far below Asia due to the low density of continental rocks, the Himalayas got pushed over a broad area, forming a high region adjacent to the mountains called the ________________________.

Since the collision began 45 million years ago, India has pushed about 1200 miles into Asia. Not only did this collision form the Himalayas, but it also resulted in adjacent parts of Asia being squeezed out to the side along major fault systems. This process is referred to as ________________________.

India is currently still pushing into Asia at a rate of a few centimeters per year, so the mountains of the Himalayas are still getting a little higher each year.

**Fault-Block Mountains**

Until now, we have looked at the formation of mountains due to compression at convergent plate boundaries. However, mountains can also form where the crust is undergoing extension, or stretching.

What type of faulting is produced by extension? ___________________________

As the footwall side of a normal fault lifts up, mountains are eventually produced. Mountains produced in this way are called ________________________.

Examples: ___________________________ and ___________________________

Prolonged extension of the western USA over the past 20 million years has occurred above a region of hot mantle upwelling, forming thousands of normal faults and associated mountain ranges in places like Nevada and Utah.
This region of extension is known as the _____________________________.

**History of the Appalachians**

In an earlier lecture, we learned that the mountain ranges of the Appalachians in North America match up with a mountain range in northern Eurasia called the:

__________________________

The reason these mountains match up was because North America, Eurasia and Africa used to be joined together before 750 million years ago as a supercontinent called:

__________________________

This supercontinent preceded Pangea, which came much later in Earth’s history.

Around 750 million years ago, Rodinia began breaking apart, just like what happened to Pangea much later, and North America began rifting away from Eurasia and Africa to form an ancestral North Atlantic ocean basin. When this occurred, a fragment of North America was rifted away from the rest of the continent.

By 600 million years ago, a subduction zone developed along the edge of this continental fragment, forming a volcanic arc. Another subduction zone formed off the west coast of Africa, forming an island arc. These two subduction zones slowly caused the ancestral North Atlantic ocean to start closing again.

The ancient fragment of North America collided with North America again between 450 and 500 million years ago, forming a suture zone with deformation and metamorphism.

What parts of the Appalachians provide evidence of this orogeny?

__________________________   and   _____________________

The plutons that formed in the volcanic arc of the continental fragment formed the core of this mountain range and can be seen at the surface today because of 500 million years of erosion.

Around 400 million years ago, the island arc between Africa and North America collided with North America, forming another mountain range. What part of the Appalachians represents the remnant of this island arc?

__________________________   and   _____________________

The final orogeny occurred between 250 and 300 million years ago, when Africa finally collided with North America, forming part of the supercontinent of Pangea.

This collision further deformed the existing mountains and began crumpling up the crustal rocks west of those mountains that originally formed off the passive margin of North America. This crumpling formed a fold-and-thrust belt that is today called the:

__________________________

Very soon after this collision, rifting began east of the mountains and the North Atlantic began forming again as Pangea broke apart. As a result, a small fragment that used to be part of Africa was left behind pasted to the eastern edge of North America.
Constructing a Continent

The plastering of crustal fragments and island arcs onto the edge of an existing continent, such as occurred in the Appalachians, has helped construct all of the Earth’s continents.

Each fragment that gets attached to the continent is called a _________________.

Before it collides with the continent, the fragment is called a ____________________.

The process by which microcontinents are added to the edges of continents is called: __________________

Microcontinents may be made up of a number of different fragments of crust, such as:

(1) ____________________ (e.g., modern day Madagascar)
(2) ____________________ (e.g., Japan, Phillipines, Aleutian Islands of Alaska)
(3) ____________________ (e.g., Hawaiian Island-Emperor seamount chain)
(4) ____________________ (e.g., Ontong-Java plateau).

Much of our knowledge of accretion has come from studies of the ____________________. Much of the western edge of North America formed due to the repeated accretion of microcontinents. As a result, there are numerous terranes along the west side of the continent.

What plate was subducting off the west coast of North America that may have brought these microcontinents into contact with N. America? ____________________

Where do we think some of these microcontinents came from based on studies of their rock types and fossils? ____________________

Based on the ages of different parts of North America, we can see that the continent has been getting progressively larger through time by the process of accretion. Similar processes shaped the other continents. We only understand the evolution of the continents because of what we have learned about modern day plate tectonics.

FINAL QUESTION:

What geologic principle are we applying when we use our knowledge of modern plate tectonics to explain the terranes that have built up the North American continent?

______________________________