

GY 112 Lecture Notes

Birth of Geology as a Science

Lecture Goals:

- A) The first “geologists”
- B) European geologists
- C) The 20th Century

Textbook reference: Levin 7th edition (2003), [Chapters 1,2](#); Levin 8th edition (2006), Chapters 1, 2 plus other stuff you don't have access to)

A) The first geologists

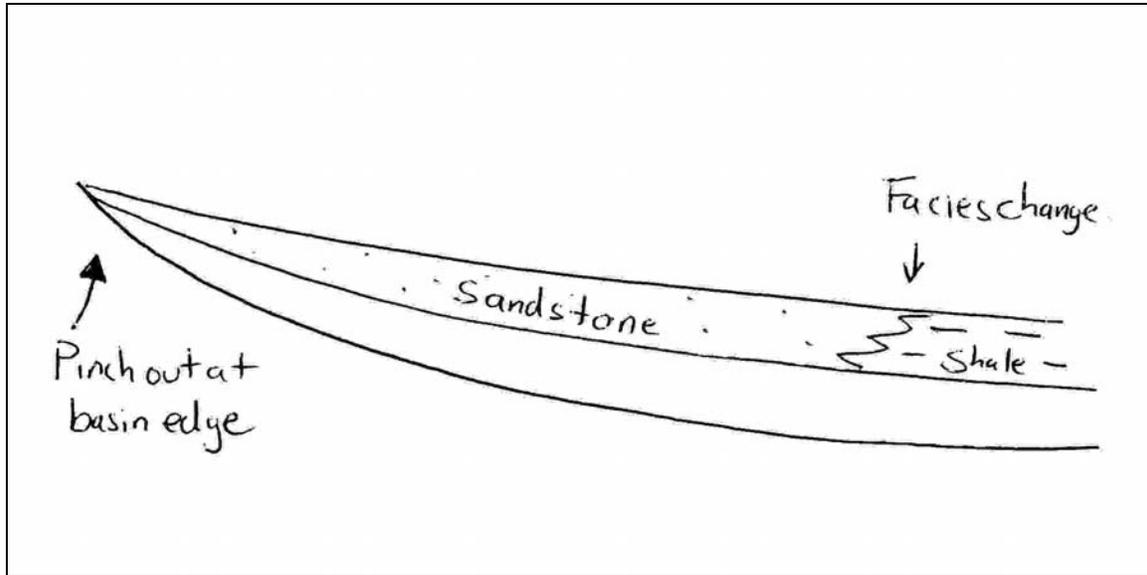
The first “geologists” didn't have a clue about what geology was. They were our earliest ancestors and back then (say 100,000 years ago), they were mostly concerned with surviving in what was frequently an inhospitable world. They used “geology” to give them a big advantage over their competitors. Our ancestors used chert, and flint and other hard minerals to make tools that they could use to hunt and built with. It is a bit more difficult to determine who the first real geologists were (e.g., those people who went out into the world specifically looking for specific geological minerals, or geological processes). The Egyptians and Greeks were certainly aware of important minerals and building stones. If you are going to build the pyramids, you want to make sure that the building stones that you are using can support the weight of the structure. And the Romans were certainly aware of geological processes (especially those that killed people). **Pliny the Younger** is generally regarded as the first person to have recorded a volcanic explosion in all its glory. He provided an account of the demise of Pompeii and Herculanium during the AD79 eruption of Mt. Vesuvius. But when we talk about the birth of Geology as a science, we are referring to the first instances when scientific reasoning was applied to those processes that shape the Earth. For this, we need to turn to 17th century Europe.

B) European Geology



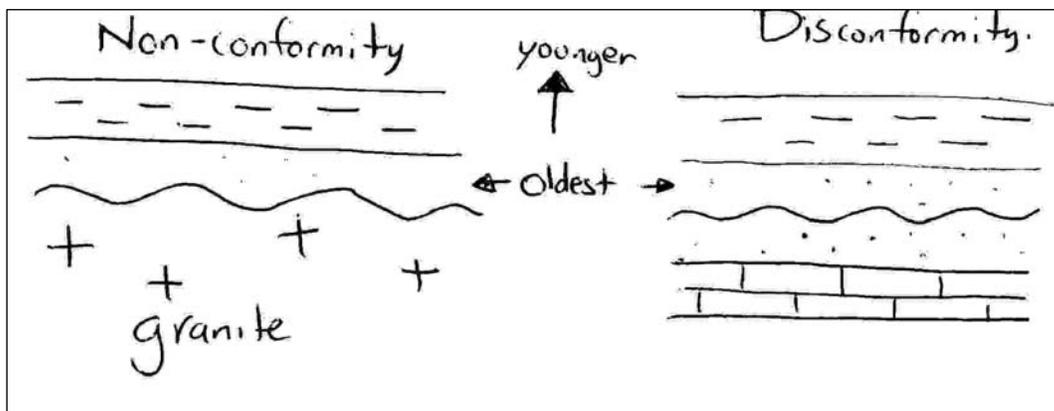
Geology as a science, like all other sciences, was born in Europe. The first scientific principles of geology were based upon stratigraphic observations. Now you have to realize that in these early times, the age of the Earth was thought to be much younger than we now know it to be. In 1658, Arch Bishop **James Ussher** calculated through extrapolation from the bible that the earth was formed on October 23rd 4004 BC at precisely 9:00 am. So when people observed rocks (especially sedimentary rocks), they assumed that everything occurred more or less at the same time. Enter **Nicolaus Steno** (1638-1687; pictured left). He worked as a physician with a member of the Danish court of royalty. He also did a lot of walking in the country side. He observed strata in the vicinity during his walks which led him to formulate 3 important axioms;

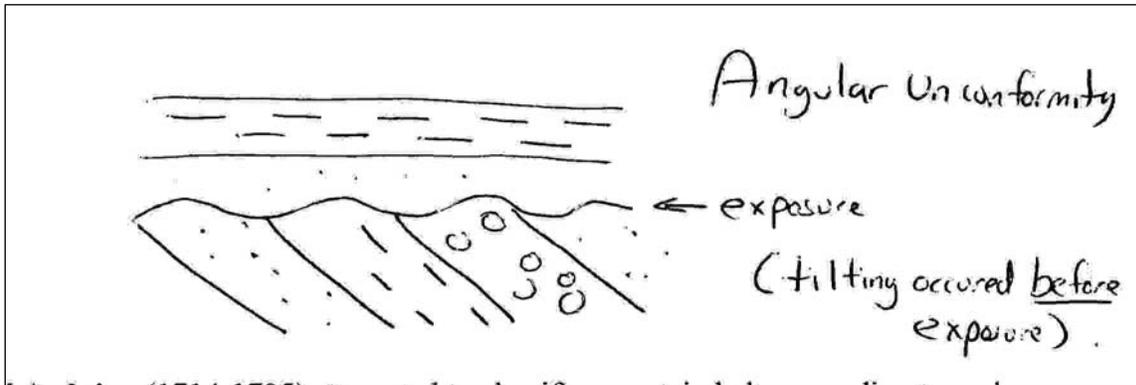
- 1) **The principle of superposition** (a favorite from GY 111!) that states *in any sedimentary succession that has not been overturned, the oldest strata occur on the bottom.*
- 2) **The principle of original horizontality** that states *sedimentary layers are originally deposited as horizontal sheets* and
- 3) **The principle of original lateral continuity** that states that *sedimentary layers are originally deposited as laterally continuous sheets that naturally terminate against basin margins or barriers or which grade into other sedimentary layers.*



All of these probably sound pretty simple and straightforward, but Steno was pretty much the first person to state these principles. As such, Steno is regarded as one of the founding fathers of the science of **stratigraphy**

John Strachy (1671-1743) was the first to fully describe **unconformities** although he did not name them as such (Robert Jameson did in 1805). These are surfaces that record a significant period of non-deposition and erosion (gaps in the geological record). Strachy made particular reference to **angular unconformities**. These involved horizontal strata resting atop the eroded edges of inclined strata. Unconformities where horizontal strata lies atop horizontal strata are generally referred to as **disconformities**. Unconformities





involving strata atop crystalline basement (igneous and metamorphic rocks) are called **non-conformities**)

Giovanni Arduino (1714-1795) attempted to classify mountain belts according to rock type. Primary Mountains were composed of igneous and metamorphic rocks and tended to form cores of mountain belts. They were also believed to be the oldest rocks within mountains. Secondary Mountains were composed of layered sedimentary rocks. Tertiary Mountains were not so much mountains but the stuff of future mountains (sand, gravel and Recent lava flows). Today we know that mountain belts are composed of all types of rocks and of variable age, but Arduino was perhaps the first person to start seeing belts within mountains. Later (in the 1960's) the true significance of mountain belts would be related to plate tectonic theory.



Abraham Werner (1749-1817, pictured) was actually a geology professor. He was a mineralogist (a geologist who studies minerals) which was a popular profession in the late 18th century, but that didn't stop him from trying to explain the origin of the entire Earth's crust. He felt that the entire crust was deposited from sea water. He felt that sea water was originally very hot and that the rocks formed from this water were enriched in minerals like quartz and feldspar (what we would today call igneous and metamorphic rocks). Sedimentary rocks (containing fossils) were precipitated from the same water after it had cooled. There were additional layers of strata including coal beds that were precipitated out of the water at a later stage. Werner insisted that all rocks were formed from a global ocean, even the igneous and metamorphic rocks which is of course silly. But it was a hypothesis. When it began to fail tests (and common sense), it was replaced by something better. One of the best ideas of a geological nature was postulated several years later by the person who I personally feel deserves the title of Father of Geology.



James Hutton (1726-1797) or “Dad” was ultimately responsible for the phrase *the present is the key to the past*, however, he never said it (a Scottish geologist did about 50 years later). Hutton said that the “past history of the Globe must be explained by what we see occurring around us today”. This is a powerful statement that was necessary to counter the general biblical belief of the time that everything on the Earth had occurred over a short period of time (e.g. the Great Flood). This was a catastrophic interpretation and those who were advocates were termed **catastrophists**. Hutton believed in **Uniformitarianism**. Most geologists today believe in Uniformitarianism, however, this does not mean that catastrophic events never occur. Asteroid impacts are

catastrophic, but they are comparably rare in the grand scheme of things (at least these days).

Hutton was also responsible for publishing one of the great books of science. The *Theory of the Earth* was published in 1785 as a summary of his ideas and others before him. I have never seen this book. I would like to. In fact I would like a copy of it. If you happen to have spare copy of it (a first edition in mint condition is preferred) please give it to me. I would die a happy man. From what I understand, the book itself is incredibly hard to interpret because Hutton wrote it in a rather rambling style. Even other geologists at the time had issues with the book.

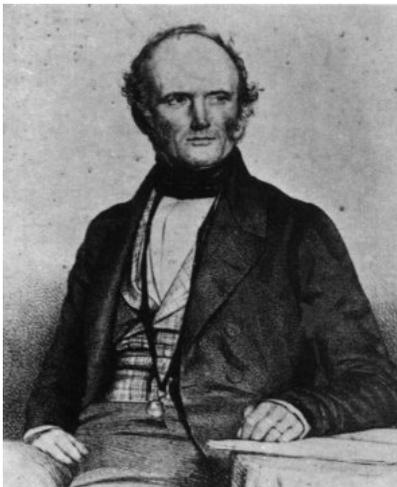


William Smith (AKA **Fossil Bill**, **Strata Smith**) (1769-1839). This man was a surveyor and map maker who worked in England in the late 18th and early 19th centuries. Although he was employed to map out springs, he really did have a love of geology. He had to. He used stratigraphy to “date” different layers of rock which was of use in his water work. He is particularly remembered for his use of fossils in dating (relatively) the different rock layers (hence the nickname Fossil Bill). By identifying specific fossils, he was able to trace specific rock layers over wide distances. However, he did not understand the beasties nor why they only occurred in certain rock types and in certain rock layers. Smith is important because he recognized that fossils could be used to keep track of rock strata. He started to correlate different rock

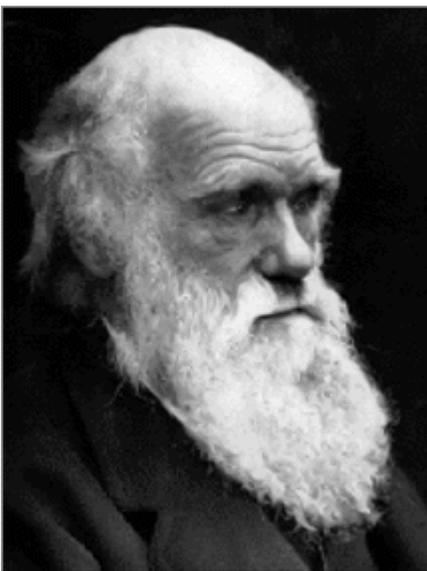
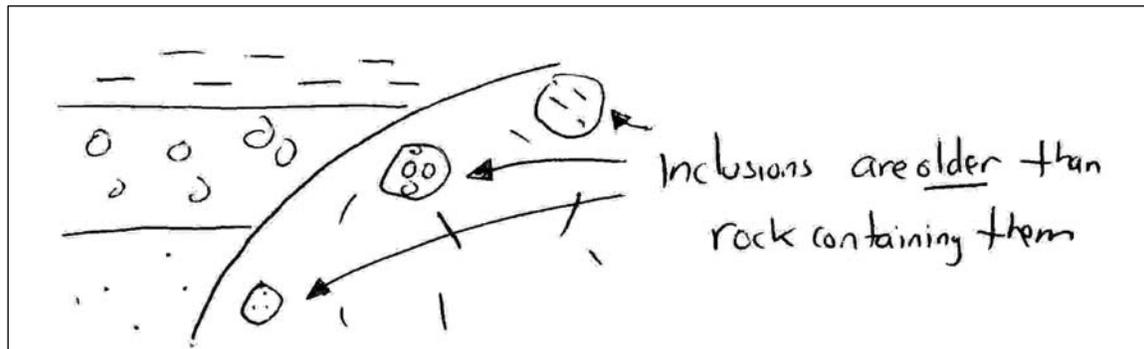
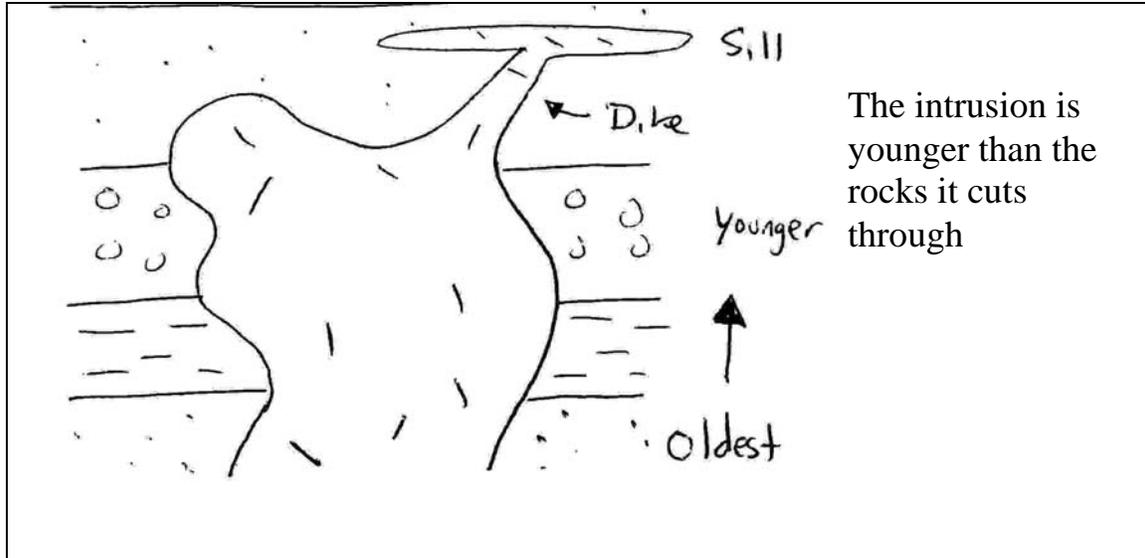
units that were deposited at the same time (the argument is that fossils were around at specific times and if two different sedimentary rocks contain the same fossils they must

have been deposited more or less at the same time; the transition represents what sedimentologists refer to as a **facies change**. Changes in type of beastie upward in a sedimentary succession (this may represent evolutionary changes or changes in depositional environment) were ultimately blended into **the Principle of Biological Succession**.

Fossil Bill is also credited with producing the first (accurate) geological map of England and Wales (see adjacent image)



Charles Lyell (1797-1875) is the only other geologist of the time that could arguably be called the father of geology. He wrote *Principles of Geology* (I would also appreciate someone giving me this book!) which ultimately became a multi-volume publication of the most important geological concepts of the time. He really did a lot to advance geology, including the recognition of relationships between rock units that were not always horizontal. His **Principle of cross-cutting relationships** recognized that in a succession penetrated by other rock units (e.g., an igneous dike cutting across sedimentary strata) the cross-cutting body is younger than the stuff it is cutting. The same can be applied to inclusions. A rock containing fragments of “country rock” (e.g. a pluton might rip off some of the surrounding rock that it is pushing through and incorporate it into the magma before cooling), must be younger than the country rock it contains. This principle is also applicable for dating unconformities and faults.



Charles Darwin (1809-1882) Darwin is generally credited with the **theory of evolution**, which is as important to geologists as it is to biologists. He also recorded some important geological observations during his sea voyages. One of these observations was made while he was in the south Pacific ocean. Darwin observed that many coral reefs occurred in the middle of the ocean in water much deeper than they could ever have started in. He saw other islands cored in volcanic rocks with fringe reefs surrounding them in shallow water. He also saw active volcanoes with thin (or little reef) growth. He reasoned that volcanoes built up to sea level which allowed reef growth, and that as a volcano died, it cooled and subsided below the surface. Coral growth kept up with the subsidence. This theory of atoll formation still stands today. Note: not all reefs are atolls.



Alfred Wegener (1880-1930) was a German Meteorologist who is credited with the first reference to **continental drift** (1915; when he published a book titled: *The Origins of Continents and Oceans*), however, much earlier (1600's), scientists had already recognized that South America and Africa had mirrored coastlines and even suggested that they had previously been stuck together. Wegener's true claim to fame is that he reassembled all of the continents into a "**supercontinent**" which he

named **Pangaea**. He was the first person to shuffle the continents around and was remarkably correct in his assembly. Two hundred and fifty million years ago (250 MA), Pangaea did exist. Unfortunately, his ideas about continental drift were not quite right, and no one really accepted the hypothesis when he published it in 1915. This was mostly because he never specified a driving mechanism to move continents around. In 1928, a Scottish geologists by the name of **Arthur Holmes** would provide it (convection currents in the mantle), but even then, it was hard for most geologists to accept. Yet you still have to give Wegener credit for the concept of continental drift, he just came up with this hypothesis long before the technology had been invented to test it. That would come soon enough and it would largely be derived from work done by researchers based in North America.

C) Geology into the 20th Century

This section is skimpy due to time constraints and many of the individuals mentioned here will be discussed again soon when we get into Plate Tectonics.

The start of the 20th century saw the development of many subdivisions in geology. The petroleum industry was initiated (remember the automobile was still new at this time) and it began to influence a lot of geological thinking. Consequently petroleum geology and sedimentology became common components of "geology". Stars in these fields included the likes of **W. Krumbien** and **F.J. Pettijohn** who together published the classic *Manual of Sedimentary Petrography* (grain size analysis etc.). I actually have a copy of this book. Unfortunately it is only a 2nd edition print. Marine geology (the study of geological processes and rocks at sea) also became an accepted subdivision of geology. **J. Shepard** (1935) and **D. Johnson** published classic books on submarine fans and submarine canyons (I have a copies of these books too!). Shepard also pioneered theories about shelf sedimentation (all before the development of detailed bathymetric testing and sampling techniques). Lets not forget the beastie-people. The stars in Paleontology included **A.S Romer** who wrote a classic book explaining evolution and of course **S. J. Gould** who is to paleontology what Stephen King is to horror stories.

During World War II, much new technology was developed to aid in the war effort. Radar and sonar had been used for the first time and after the war, scientists began to look for new (peacetime) uses for these techniques. For the first time, very accurate water depths could be quickly made over large areas of the sea floor. Cruises across oceans showed that they were anything but flat. There were linear trenches and linear mountain belts. A picture of the world was building up and it was starting to look pretty strange. New geophysical techniques were being developed (almost daily) and the volume of data was steadily increasing. 1957-1958 was declared the **International Geophysical Year (IGY)** which saw an organized attempt by countries around the world to concentrate their research efforts on all things geophysical. Satellites were launched to study the sun, the moon and the Earth (magnetic field etc). But there was also a start in understanding how the interior of the Earth worked. It was during this time that paleomagnetic surveys of ocean crust started to become commonplace and they began to show irregularities in paleomagnetism. Actually they were hardly irregular; the seafloor could be described as a series of paleomagnetic stripes. This of course was an important support for plate tectonics, an hypothesis that was floating around out there but which had let to be fully thought out. But that is story for another time.

Important terms/concepts from today's lecture

(Google any terms that you are not familiar with)

People:

Ussher
Pliny the Younger
Steno
Strachy
Arduino
Werner
Hutton
Smith
Lyell
Darwin
Wegener

Principles:

Original Horizontality
Lateral Continuity
Superposition
Biological Succession
Cross-cutting Relationships
Inclusions

Terms:

Stratigraphy
Unconformity (Angular unconformity, Disconformity, Non-conformity)

Catastrophism
Uniformitarianism
Atoll
Pangaea
International Geophysical Year
Paleomagnetism