Content

• Origin of our solar system and the earth; structure of the earth

---- Development of the geological world view

- Introduction to mineralogy I: elements, sulfides, oxides, carbonates etc.
- Introduction to mineralogy II: Silicates
- Rocks I: Magmatic and metamorphic rocks
- Rocks II: Sediments
- Age determination: relative ages; absolute ages
- Plate tectonics and volcanism (e.g. endogenic processes)
- Exogenic processs
- Environmental archives
- Ore deposits
- Geology of Chile
- Final test and feed back

Oldest geological map of the world

Turiner Papyrus:

Sketch-map of an Egyptian mining area (about 1320 B.C.) *Mountains,* where gold has been washed, are in dark color.



Raw materials in the Stone and Bronze Age

Stone Age / Bronze Age / Antiquity – Mining in:

- Flint chert (France, England, Denmark, Belgium) figure,
- Obsidian (volcanic glass)
- Salts
- Metals (Au, Ag, Cu, Sn, Pb)
- Building (dimension, cut) stone
- Clay for ceramic figure
- Decorative stones

Figure right:

Antique representation of the clay-extraction at 6. B.C. in Greece [18-1]



Source: Professur am Lehrstuhl für Geologie; TU-Dresden

Historical underground mining



Ground view (left, I-VI = shafts with mining gallery) and reconstruction of the shaft II (right, A, B, C = Gallery entrances, St = fireplace) of a stone-age chert mining (Cissbury, England) [18-1]

624 to 470 B.C.: Ionian natural philosophers \rightarrow Sedimentations and erosion process. All deposits from the see.

430 to 300 B.C.: metaphysical speculation Greek philosophers (among others Plato and Aristotle)

Aristotle (384 - 322) represents in his work "Meteorologia" the doctrine of transformation (Transmutation) of the elements. He led back the transformation from the deep penetration of the sun's rays in the earth. From the consequential dry exhalations result the rocks and from the wet exhalations the metals. He had know the elevation and depressions of the earth's surface, and the accretion and abrasion. In his opinion, they were based on the slow but irregular aging process of the earth.



Aristoteles [18-1].



The discovery of the specific weight of gold, by <u>Archimedes from Syracuse</u> (about 285 - about 212) in the bathtub, is considered the first quantitative measurement in Physics.

The last major summary of this material, meanwhile very extensive and contradictory, undertook <u>Pliny the Elder</u> in his encyclopaedic *Naturalis Historia*. The last five books dealing whit the mineral Kingdom.











The large Vesuvius eruption 79 B.C. and the destruction of Pompeii

First accurate description of a volcanic eruption by Pliny the Elder (who died in) and his nephew Pliny the younger during the eruption of <u>Vesuvius</u>, which destroyed the city of <u>Pompeii</u>: → Plinian eruptions







<u>Theophilus of Antioch</u> (115 – 181 A.C.) rejected the old Greek ideas about the eternity of the world. Thus, in the Christian Late Classic Period many old conceptions about the nature of the Earth were lost, much like the millennial cycles of the earth formation and earth destruction. Instead, he calculated according to the Jewish model and according to the Bible an age of 5529 B.C.

Lactantius Firmianus (ca. 240 – 320 A.D.) denied the ball shape of the earth, and favored a <u>surface-earth-theory</u>, as suggests the <u>Old Testaments</u>.

Ibn Sina (980-1037) and his religious order teaching, that the oceans filled over long periods with sediment from the mountains and rivers. Finally, the ocean overflow and new material is deposited at the continent.

Leonardo da Vinci (1452 - 1519) discovered the organic nature of fossils, at which he clearly denied the importance of the biblical diluvium for the process. Similarly, he rejected the short age of the earth calculated from the Bible and observed the different sedimentation of sand grains in flowing water. The Leonardo's notebooks were never published and so remained his findings practically ineffective. At the beginning of the modern geology is essential therefore the work of <u>Georgius Agricola</u> (<u>1494</u> - <u>1555</u>). The main part of his work *De re metallica libri XII* consists of detailed descriptions of the former mining and engineering, the construction of furnaces, the production of soda, saltpeter, sulfur and alum, the transport of ore, wind and hydropower, but also legal and administrative matters.

Georgius Agricola (1494 -1555):

• Characteristic of the distinguishing feature for the minerals (color, brightness, smell, hardness, fusibility, magnetism, shape).

• Explication of the mineral formation by means of changes in the temperature of solutions and melting "... the rocks, that the water by means of wetting dissolves, that had the heat by means of drying-out assembled, whereas in contrast, the rocks, which the heat of the fire melt, ...by means of the cold compacted are."



• Minerals classes after AGRICOLA:

GEORGIUS AGRICOLA [18-1]

Aggregate A	Rocks	Soils	Aggregate B	Mixture	Metals
Oil Coal Amber	Magnesite Asbestos Marble Jewel	Clay Ocher Healing- earth	Rock salt Sulfur	Sulfides of Ag, Hg, Fe, Pb	Metals Alloy

Athanasius Kircher gave a good summary of how was the interior of the earth for an educated man of the 17.th century. The terrestrial body is not only crossed through flocks of fire, but also by underground rivers and lakes.



Athanasius Kircher merit lies in the didactic ably placement of an image of the earth according to the era. With his work he achieved an enormous broad effect that goes far beyond the 17th. Century. Kircher's reflections, where however whole to conform to the biblical history of the Creation, after that the earth has been created in six days. Thus his work not marked the beginning of a new development, but the end of an era. Only a few years after the appearance of MUNDUSS SUBTERRANEUS in 1665, published the Dane Niels Stensen (Nicolaus Steno) the PRODROMUS (1669), in which he formulated for the first time the law of the superposition – younger lie on older \rightarrow concept of time of the geology

Okrusch & Kleber 2002



Plegräische fields by Nepal (Drawing Athanasius Kircher)

Okrusch & Kleber 2002



Nils Steno (1638 – 1687) draw in 1669 the first geological profile up in Tuscany → First step in the direction of a history of the earth. stratigraphical principle ,, younger is on the older" later he converted to Catholicism and died as destitute missionary



Nicolaus Stensen (Steno, 1638 – 1687):

- Doctor, Denmark, Copenhagen, he lived a long time in Tuscany.
- 1669 first geological profile of the geological evolution of Tuscany.
- Concept of the horizontal sedimentations of the rocks in the water.
- Deformations take a place later by means of inner forces of the earth.
- Formulation of the stratigraphical basic law, stratification law, principle of superposition (overlying/underlying).
- Observation of the relationship between determined fossils and layers.
- Mineralogy (Figure):
 - Anisotropy of the mineral properties,
 - Description of crystals of quartz and hematite,
 - Law of constancy of the crystal angle.



Description of crystals of quartz and hematite after Stensen (1669) [18-1]



North-south profile throughout the landscape of the South Harz foreland by Nordhausen and the stratigraphic sequence after Lehmann (1756), taken from [18-1]. A-k= Permian layers with the mountains of the Ilfelder porphyry; I-n: Zechstein layers with gypsum mountains near Niedersachswerfen.

J.C.W. Voigt (1752 -1821):

• Weimar volcanologist: "Mineralogical trip throughout the Ducal Weimar and Eisenach." (Dessau, 1785), geological section from the Rhön to Halle's Porphyry.



Profile of the Rhön (left) across the Thuringian Wood, Ettrsberg, Finne to Halle's porphyry complex from J.C.W. Voigt [18-2].



Landscape and tectonic constitution of Hainleite, Kyffhäuser and Südharz with golden meadow, little golden meadow (near Frankenhausen) and Wippertal [18-2]



Basic work method of the geological mapping by the geodesist and canal constructor William Smith (1769 - 1839).

In **1815** was published his monumental colorful map of the geology of England and Wales. The map considered the fossil content as well as the lithology.

→ It gave the direction to future projects of the respective national offices.

The geologic map become gradually so into a complex representation of four dimensions (three of space and the time).



William Smith's Geologic Map of part of England



The world view of the Neptunism:

this view considered the diluvium as a single event, which had changed considerably the shape of the earth after the Creation. Accordingly, the formation of the rocks was propagated from the water and from a kind of primeval ocean. Volcanoes were only small smoldering in the sediment layers of a primeval ocean.

James Usher (1580 - 1656) dated the formation of the world at Monday 23 October 4004 B.C.

For Neptunist was a problem to explain, why were the fossils embedded deep in the rocks, rather than to lie on the surface. One way was, to deny the organic origin of the fossils, and they as spontaneous creations and curious nature games to explain (e.g. Martin Lister 1638-1711).

Robert Hookes (1638 - 1703) idea, that the fossil content of the rocks could be linked to a temporal sequence of changing environmental conditions, was not initially considered.

Platonism versus Neptunism "The basalt conflict"

Abraham Gottlob Werner

Particularly the study of the guide fossils led to another, long-lasting controversy about the role that catastrophic events have in the history of the earth. The main representative of the <u>cataclysm theory</u> was <u>Georges de</u> <u>Cuvier</u> (1769–1832).

James Hutton Main representative of Platonism view of the world

Werner's students included famous names such as <u>Alexander von Humboldt</u>, <u>Franz von Baader</u>, <u>Leopold</u> <u>von Buch</u>, <u>Friedrich Mohs</u>, and <u>Robert Jameson</u>.

Abraham Gottlob Werner:

- Explication of geological events according to the vision of the Neptunism.
- Water is the exclusive determinant geological agent.
- Rocks result from chemical or mechanical precipitations of the water. It is valid too for plateau basalts of the ore mountains (Fig.)
- Theory of the sinking primeval ocean level.
- Classification of the earth history according to mere petrographical aspects. The rest of organisms are not considered.

Lehrstuhl für Angewandte Geologie (TU-Dresden)

Alexander von Humboldt

scientific Jack of all trades possibly example for interdisciplinary thinking

The concept of <u>Actualisms</u> was developed for Sir <u>Charles Lyell</u> (1797–1875). His main work Principles of Geology appeared at first in 1830. Based on the ideas of James Hutton, Lyell reasoned that the geological time scale is very long in comparison with the human history. Moreover he presumed that the process, which controlled the formation of certain rocks, are mainly identical to the process that can be still observed at the present. (*"The present is the key to the past"*)

<u>Charles Darwin</u> (1809 – 1882) helped to put the Actualism back on the map. He had in his younger days a formal, even though shortly, education as geologist. His explication for the formation of the <u>Atolle</u> is even today accepted. However, his major work, the theory of evolution, is essentially based on the actualism principle of Lyell. Only by means of the comparative study of today living organisms, he provided the <u>Paleontology</u> of a solid theoretical background.

First global Hypothesis for the orogenesis

<u>Carl Spitzweg</u>: The geologist, about 1860

1873 presented the Americans Actualist J.D. Dana (1813 - 1895) the Geosynclinals-theory. These remained, far into the 20th century, the relevant tectonic explanatory model. In Europe, Eduard Suess (1831 - 1914) helped with his works about the Alps, that such conceptions were accepted. With Suess turns back too the differentiation of the worldwide orogenesis phases. The well-know are the Caledonian, Variscian and Alpidic orogenies. Hans Stille (1876 - 1966) represented successful still into the nineteen-twenties the Contractionshypothesis, according to which the orogenesis is foremost generated due to the contraction of the terrestrial body (<u>Stille-Cycle</u>).

Until 20th mid-century have been proposed the more different geotectonic hypotheses. For example the <u>Pulsations-hypothesis</u> \rightarrow alternated phases of contraction and expansion of the earth. Or the <u>Oscillations-hypothesis</u> \rightarrow increases of vertically isostatic compensating movements in the earth crust. Such as their precursors, all these hypotheses come from a firm <u>fixation</u> of the earth crust with the background.

About 1900 <u>Emil Wiechert</u> (1861 - 1928) inferred from seismic dates the shell structure of the Earth with <u>earth's core</u>, <u>Mantle</u> and <u>Crust.</u>

By placing of the first undersea telephone cable from England to North America at end of 19th century was discovered the Mid- Atlantic Ridge. However, a long time, it did not draw conclusions from the fact that the Ridge draft shore parallel from north to south throughout all the ocean, instead of, as in effect could have been expected, to join the continent by both sides of the Atlantic in East-west direction.

Alfred Wegener views about the continental drift

Theory of continental drift

In 1915 Alfred Wegener (1880–1930) published the book *The Origin of Continents and Ocean.* He inferred from the precise fitting of the shore lines of South America and Africa (still better fitted the shelf margins), that these fragments could have been in the past a bigger continent, which was broken up in the past (geological time). Aside Wegener accumulated more arguments:

Folding belt and shear zones from South America are comparable to very similar chronolithologic units and deformation patterns in Africa.

Diamante deposits in South America and West Africa show geological similitude. In all south continents are found permo-carboniferous glacial stage traces, among too parallel glacial trails.

Agreement of certain fossils and recent floras and faunas on both sides of the Atlantic:

Fossils land plants with tongue shaped leaves (<u>*Glossopteris*-Flora</u>) were disseminated in all south continents.

Fossils relicts of <u>Mesosaurus</u>, a freshwater reptile, could be detected in Africa as well as South America.

Die sea cow <u>Manati</u> appears today in West Africa as well as in Central and South America.