Engineering Geology CE1301

Lecture #1 Introduction & Architecture of the Earth Surface

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References

- West, T. R. (1995). **Geology Applied to Engineering**. 1st Edition. Waveland Pr Inc. ISBN-13: 978-1577666554.
- Blyth, F.G.H. and de Freitas, M. H. A. (1984). **Geology for Engineers.** 7th Edition. Elsevier Butterworth-Heinemann. ISBN 0 7131 2882 8.
- Waltham, T. (2003). **Foundations of Engineering Geology**. 1st Edition. Taylor & Francis e-Library. ISBN 0-203-78043-4.
- Bell, F. G. (2007). **Engineering Geology**. 2nd Edition. Butterworth-Heinemann is an imprint of Elsevier. ISBN-13: 978-0-7506-8077-6.
- Lisle, R. J. (2004). **Geological Structures and Maps**. 3rd Edition. Elsevier Butterworth-Heinemann. ISBN 0 7506 5780 4.
- Weijermars R. (1997). **Structural geology and map Interpretation**. 1st Edition. ISBN-90-5674-001-6.
- Hudson, J. A. and Harrison, J. P. (2000). **Engineering Rock Mechanics -An Introduction to the Principles.** 1st Edition. Elsevier Science. ISBN: 0 08 04 19 12 **7.**
- Look, B. G. (2007). **Handbook of Geotechnical Investigation and Design Tables**. Taylor & Francis/Balkema, e-book. ISBN 13: 978-0-203-94660-2.

What is Geology

- **Geology**: The science of Geology is concerned with the Earth and the rocks of which it is composed, the processes by which they were formed during geological time, and the modelling of the Earth's surface in the past and at the present.
- **Engineering geology**: is the application of the principles of geology in engineering field for the purpose of assuring that the geological elements such as the location, planning, design, construction, operation and maintenance of engineering projects are considered.
- **Economic geology**: deals with the Earth's natural resources, in terms of location and management, such as petroleum and coal, and minerals resources.
- **Mining geology**: deals with the extraction of minerals from the ground for industrial and economical benefits. This includes mining for minerals, gemstones, metals, .
- **Petroleum geology**: deals with the subsurface exploration for the purpose of locating extractable hydrocarbons, such as petroleum and natural gas.

Relevance of engineering geology to civil engineering

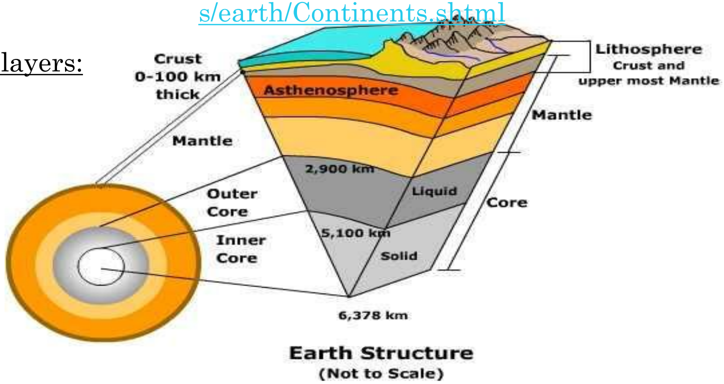
- Knowledge of **construction material**, its occurrence, composition, durability and other properties. Example of such construction materials is building stones, road metal, clay, limestones and laterite.
- Helps in planning and carrying out major **civil engineering works which can be affected by natural agents such as water, wind, ice and earthquakes**. For example the knowledge of erosion, transportation and deposition helps greatly in solving the expensive problems of river control, coastal and harbour work and soil conservation.
- Knowledge of **ground water** (quantity and depth of occurrence) is the water which occurs in the subsurface rocks.
- **In checking foundation stability of engineering constructions**. Stability of dams, bridges and buildings are directly related to the geology of the area where they are to be built.
- **In slopes and cuts stability**: important in tunnelling, constructing roads, canals, docks and in determining the stability of cuts and slopes, the knowledge about the nature and structure of rocks is very necessary.
- **In preparing geological maps and sections for engineering constructions**: Before staring a major engineering project at a place, a detailed geological report which is accompanied by, is prepared. Such a report helps in planning and constructing the projects.
- **In the study of soil mechanics**, it is necessary to know how the soil materials are formed in nature.
- The **cost of engineering works will considerably reduced** of the geological survey of the area concerned is done before hand.

EARTH'S LAYERS

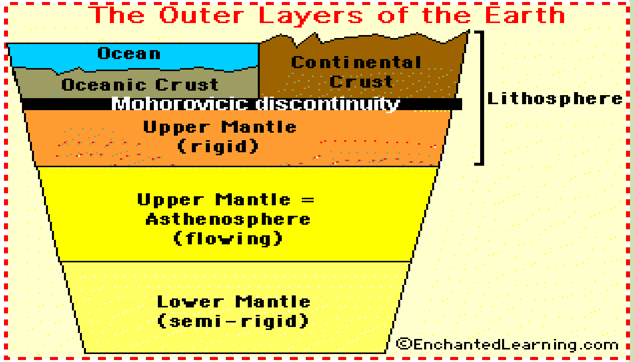
[Source:http://www.enchantedlearning.com/subjects/astronomy/planets/earth/Continents.shtml](http://www.enchantedlearning.com/subjects/astronomy/planets/earth/Continents.shtml)

Earth is comprised of the following layers:

–The Crust:
• Continental
• Oceanic
–The Mantle.
• Upper
• Lower
–The Core.
• Outer Core.
• Inner Core.



Earth Structure
(Not to Scale)



The Crust: The outermost layer of Earth with variable thickness.
–Thickest under mountain ranges (70 km).
–Thinnest under mid-ocean ridges (3 km).
• The Moho discontinuity is the lower boundary which separates the crust from the upper mantle.

Earth's Mantle: Solid rock layer between the crust and the core.
• 2,885 km thick, the mantle is 82% of Earth's volume.
• Below ~100-150 km, the rock is hot enough to flow.
• It convects: hot mantle rises, cold mantle sinks.
• Three subdivisions: rigid, flowing, and semi-rigid.

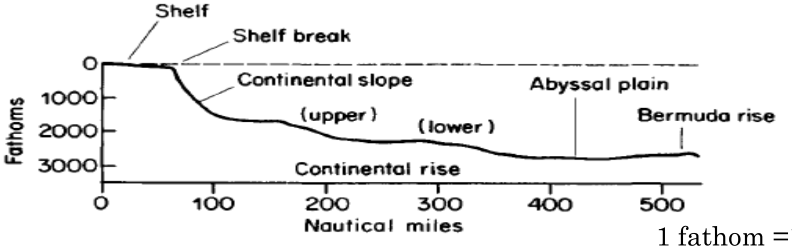
The Core: An iron-rich sphere with a radius of 3,471 km.

–Outer core
• Liquid iron-nickel-sulfur
• 2,255 km thick
• Density – 10-12 g/cm^3

–Inner core
• Solid iron-nickel alloy
• Radius of 1,220 km.
• Density – 13 g/cm^3

Dimensions and surface relief

- The radius of the Earth at the equator is 6370 km and the polar radius is shorter by about 22 km; thus the Earth is not quite a perfect sphere. The planet has a surface area of 510 x 10^6 km^2, of which some 29 per cent is land.
- Surface topography is very varied; mountains rise to several kilometres above sea level, with a maximum of 8.9 km at Everest. The average height of land above sea level is 0.86 km and the mean depth of the ocean floor is about 3.8 km.
- The topographical features of a continental margin, such as that of the North Atlantic is as shown below.



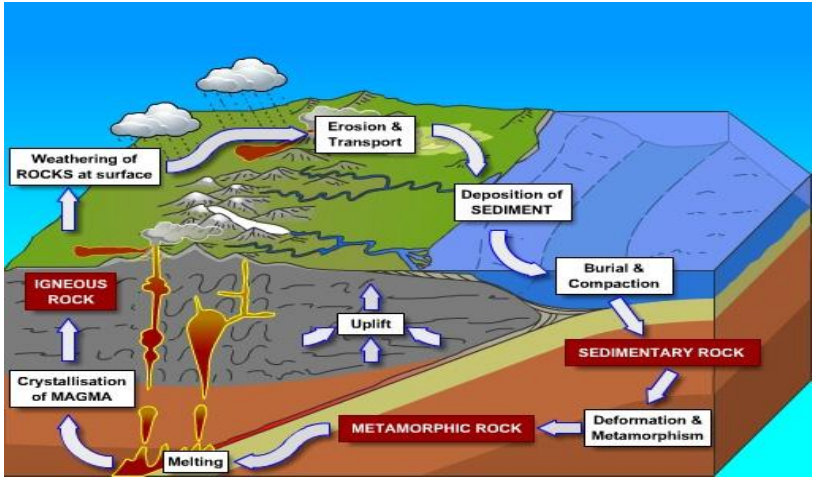
1 fathom =1.8288 meters

Source: http://www.geolsoc.org.uk/ks3/gsl/education/resources/rockcycle.html

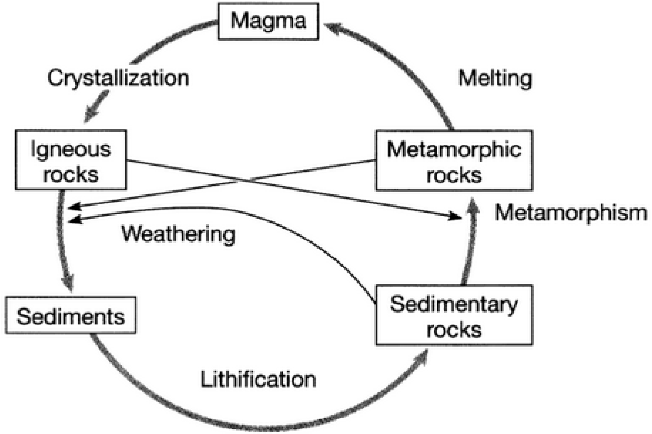
ROCK CYCLE

Rock types

- **Igneous Rocks** are formed by cooling magma or lava *(lava is a magma which cools on earth's surface).*
- • **Sedimentary Rocks** are formed by the chemical precipitation of mineral grains; or by the sedimentation and cementation of fragments of plants, animals or other rocks, transported by water, wind or ice to a site of deposition.
- • **Metamorphic Rocks** are formed after a rock is subjected to intense temperatures and/or pressures, resulting in the transformation of original compounds (minerals) and/or textures (grain size).



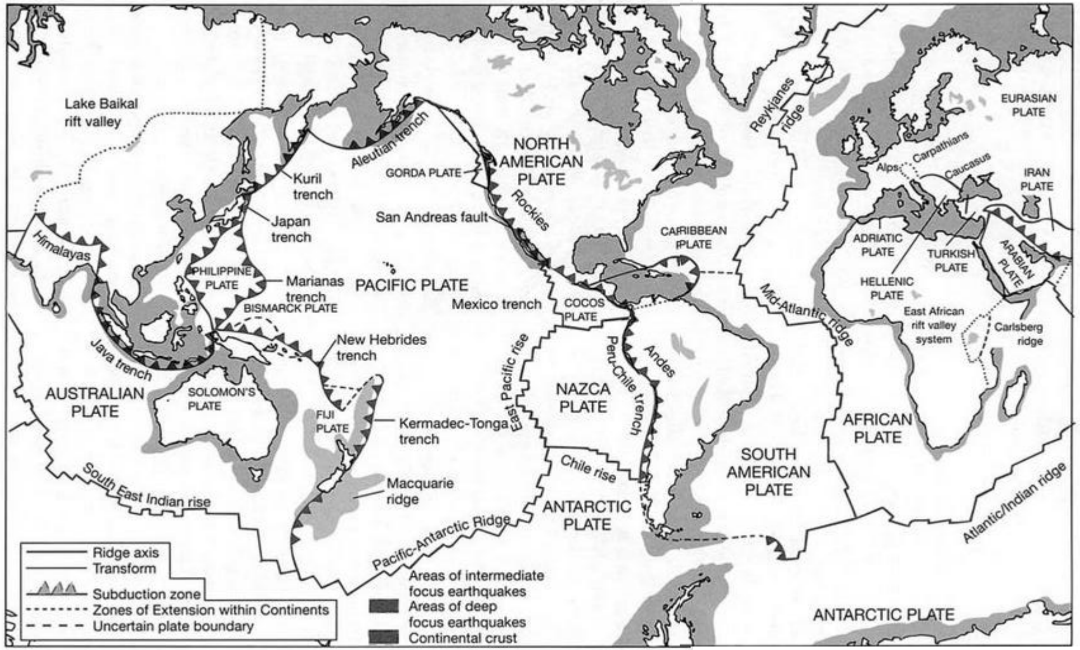
- ➢ Beginning with magma, crystallisation yields igneous rock, which can be either intrusive or extrusive.
- ➢ These rocks can weather, giving broken rock fragments. When sediments become lithified, they give sedimentary rocks.
- ➢ Metamorphism of these rocks produces metamorphic rocks, which in turn, on melting provide magma once more.
- ➢ Shortcuts across the cycle are shown: igneous rocks can be metamorphosed to metamorphic rocks. Sedimentary rocks and metamorphic rocks can be weathered to sediments.



Architecture of the earth surface

- The continents would fit together if they merely moved around. For example, south America could be slipped under Africa.
- Seafloor spreading and plate tectonics occurred during the past 200 million years contributed to this separation.
- **Lithospheric plates:** are rigid slabs consisting of a continental and/or oceanic crustal cap plus part of the underlying mantle. Continental plates or oceanic plates extend thousands of kilometres across but only 100 to 200 km thick).
- **Plate tectonics:** refer to the movement that occur at the boundaries plates, caused by the underlying weak and plastic zones known as asthenosphere.
- The earth surface is divided to 8 large plates and 12 other small plates

Plates and plate boundaries of the earth



There are 3 basic types of plate boundaries:

1) The **zones of divergence** or spreading, that is the typical ocean ridges;
2) The **transform margins** where plates slide sideways past each other, and
3) The **zones of convergences** where the plates move directly toward each other.

- Most deep-seated earthquakes occur mostly along the zones of convergence.
- Plate tectonics are important for many aspect of a global significance, such as: volcanoes, earthquakes, folded mountains, continents, etc.

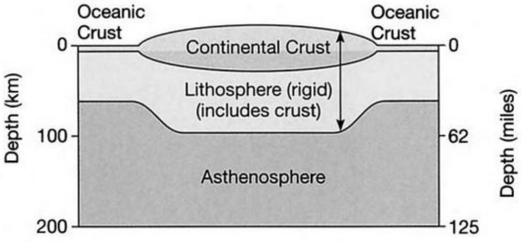


FIGURE 1.5 Cross section of the upper portion of the Earth, showing the continental crust, oceanic crust, lithosphere, and partially molten asthenosphere.