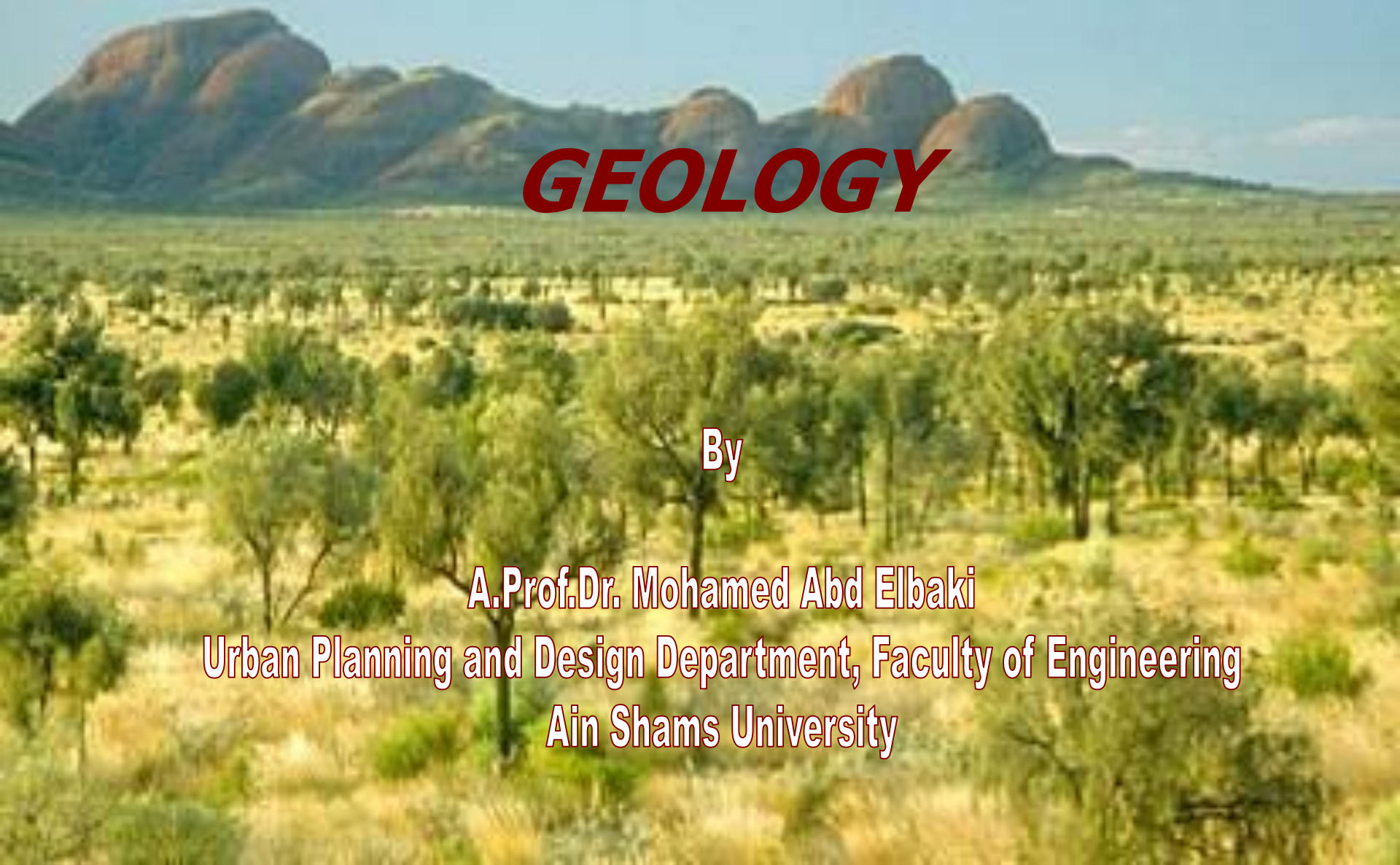


GEOLOGY

By

A.Prof.Dr. Mohamed Abd Elbaki

Urban Planning and Design Department, Faculty of Engineering

Ain Shams University

A View of Earth

The Earth is a closed system.

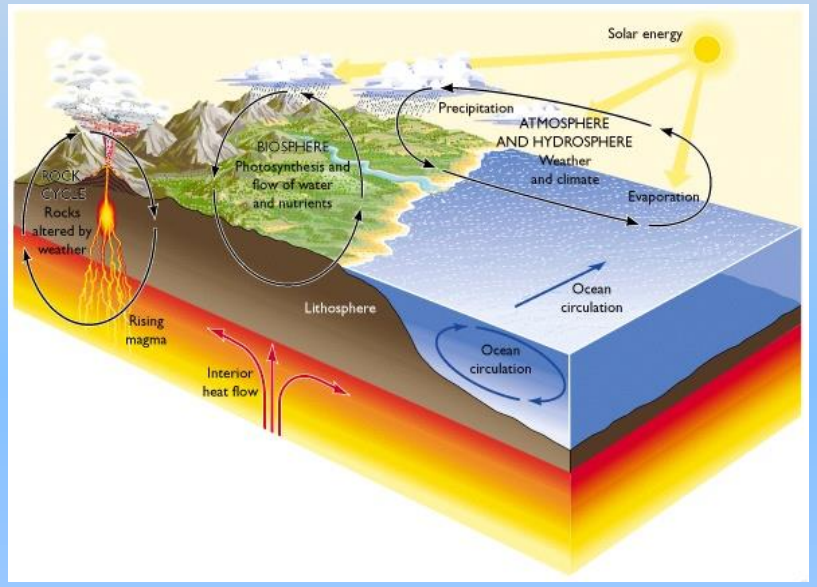
There are four spheres (system) around the earth, each is an open system:

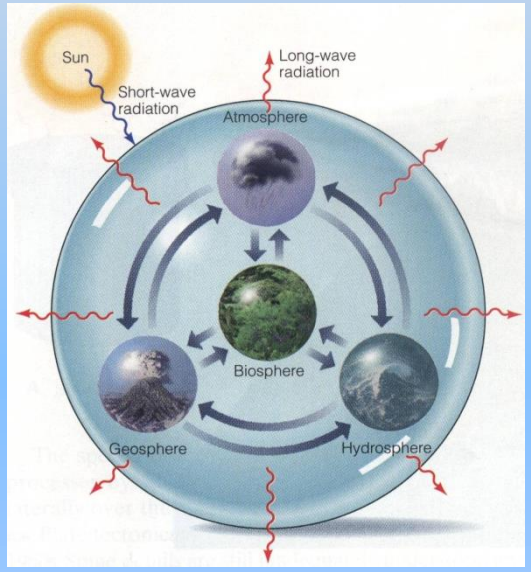
1- Atmosphere

2- Hydrosphere

3- Biosphere

4- Geosphere

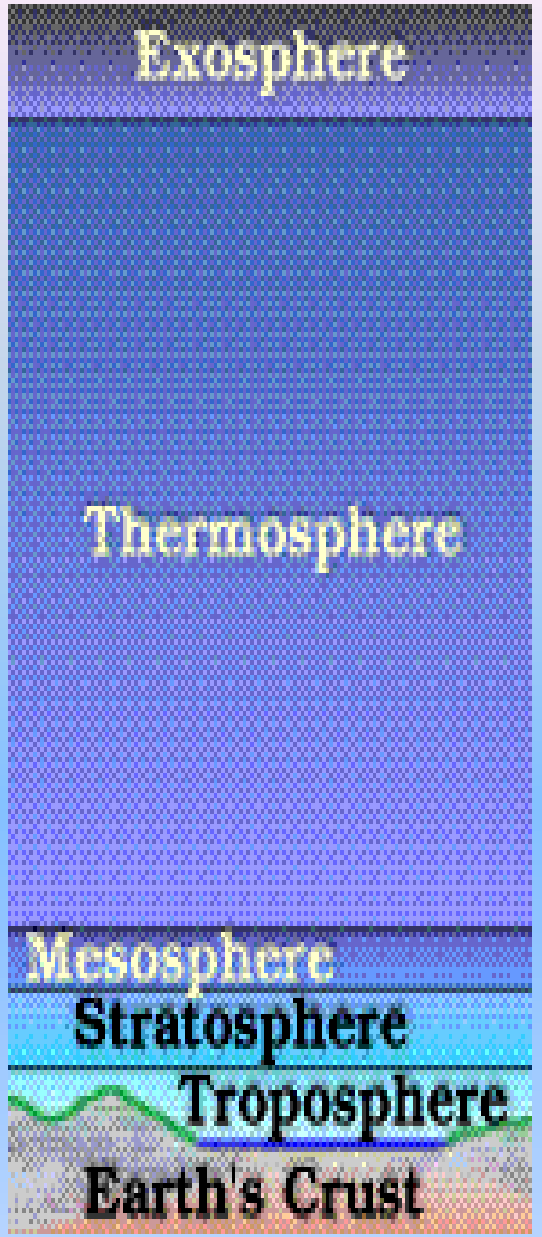




The Earth is essentially a closed system. Energy reaches the Earth form an external source and returns to space as long wavelength radiation. Smaller systems within the earth; atmosphere, hydrosphere, biosphere and geosphere are all open system.

Atmosphere

- It includes the air envelope surrounding the earth. It is important for breathing and for protection against sun's heat and ultraviolet radiation.
- It is a mixture of gases predominantly nitrogen, oxygen, argon, carbon dioxide, and water vapor.
- It is divided into several layers arranged from the earth's surface into Troposphere, Stratosphere, Mesosphere, Thermosphere and Exosphere.



Hydrosphere

It includes all water bodies on the earth such as the oceans which constitute about 71% of the earth's surface, the fresh water streams, lakes as well as the underground water. Fresh water is very important for life and also responsible for sculpting and creating many landforms on the earth.

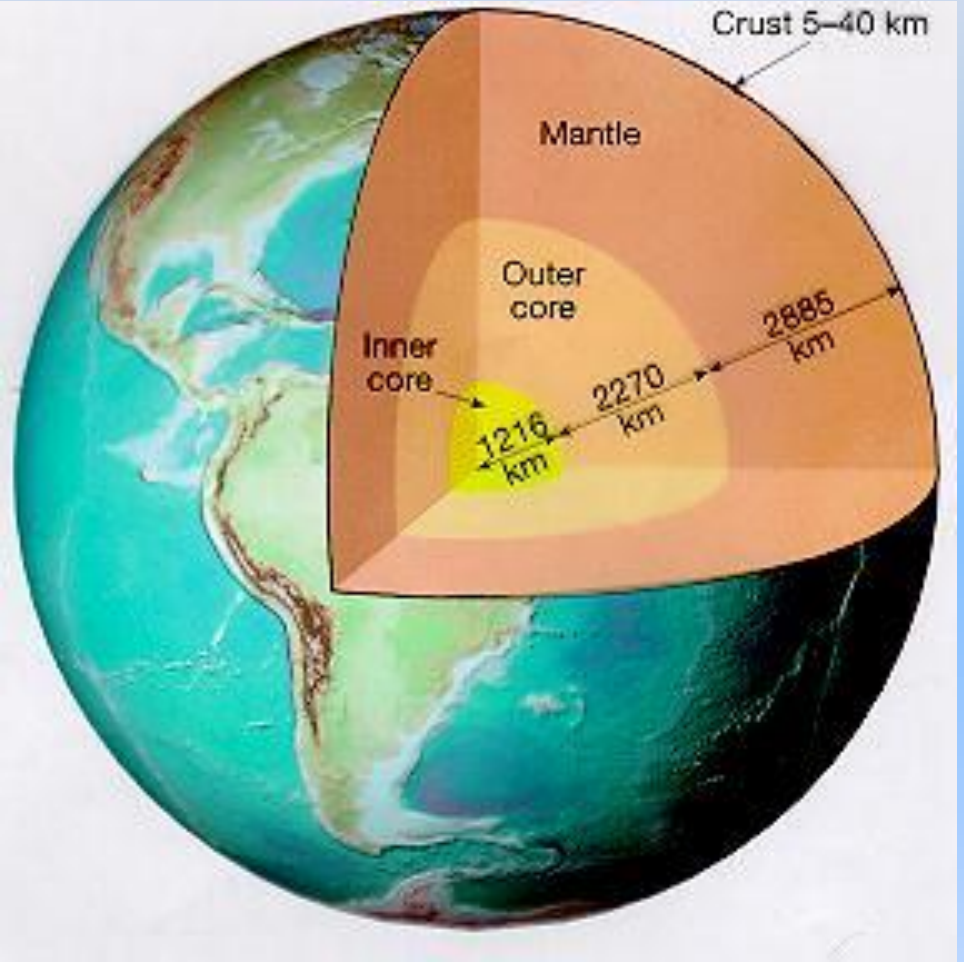
Biosphere

It includes all life on the earth either plant life or animal life, in the sea or on land.

Geosphere

"Earth's Internal Structure"

Earth's interior consists of three major regions that have markedly chemical composition, these three regions are called crust, mantle and core.

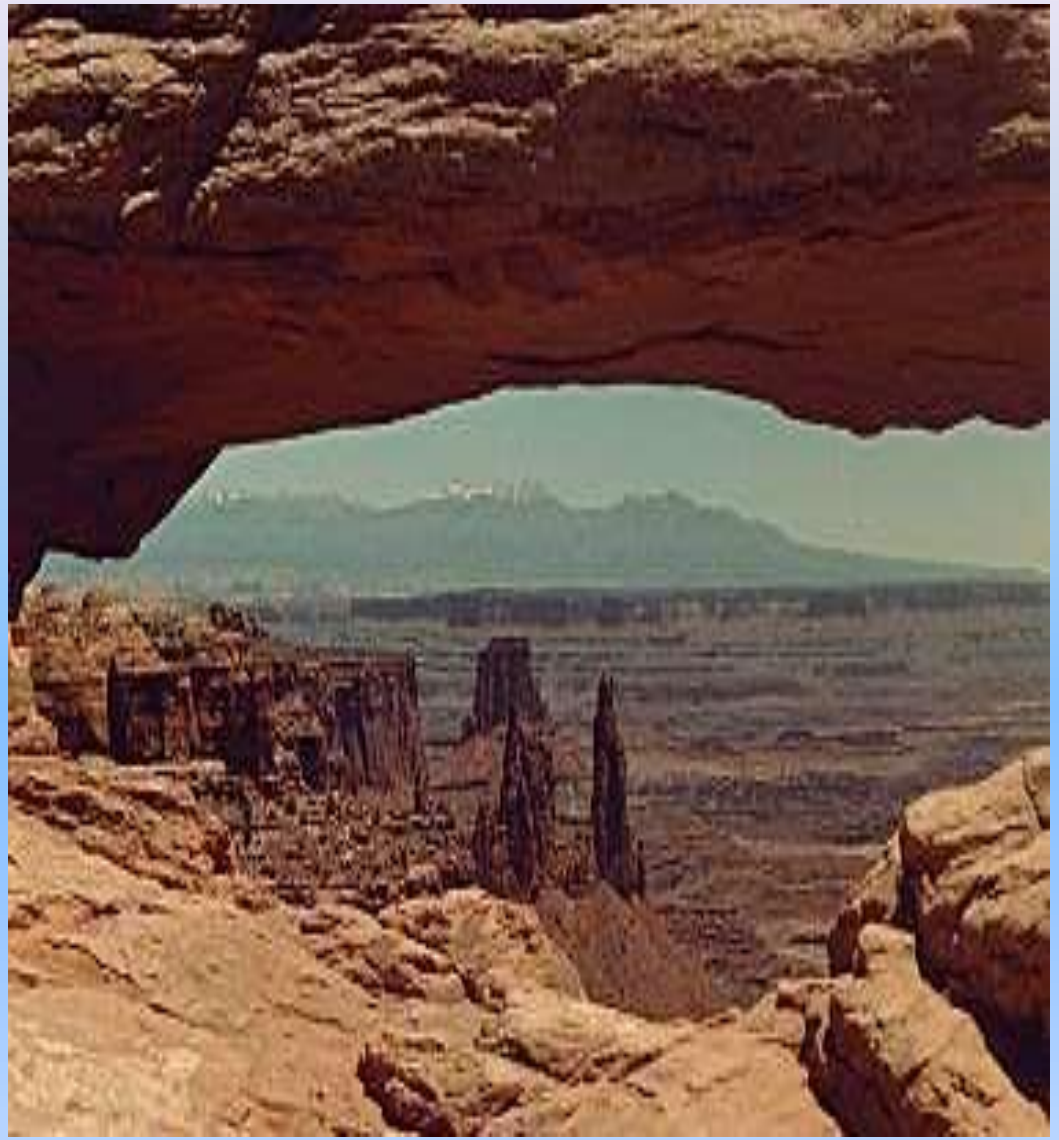


- **Geology (general concepts)**
  - **Earth Composition**
  - **Tectonic Plates**
  - **Time in Geology**
  - **Rock Types & Cycle**

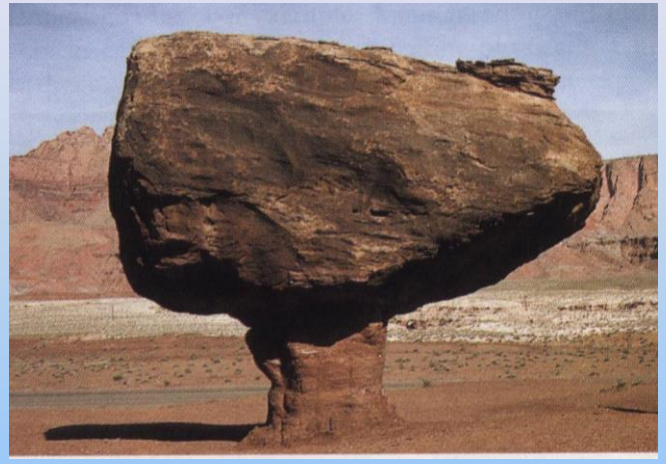
Geology

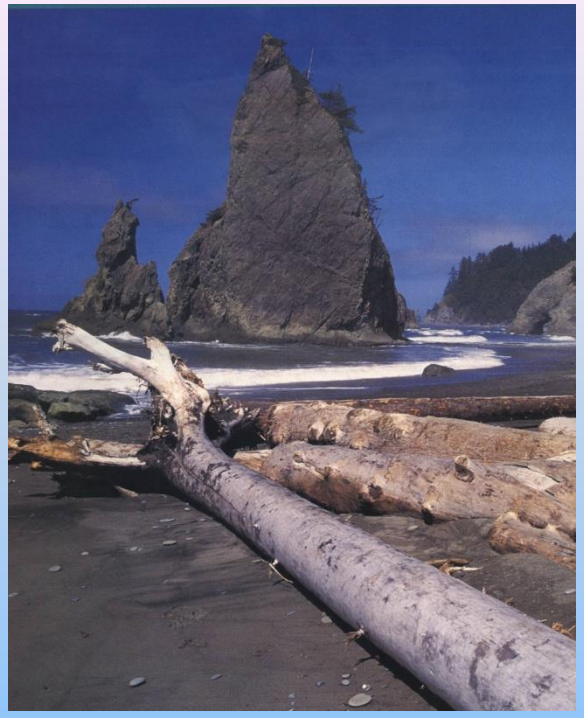
The science of Geology is concerned with the Earth and the rocks of which it is composed, the processes by which they were formed during geological time, and the modelling of the Earth's surface in the past and at the present day.

Environmental geology applies geologic principles to understanding and solving problems that arise from these human-environment interactions.



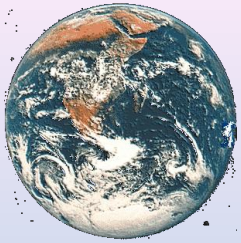
Geology



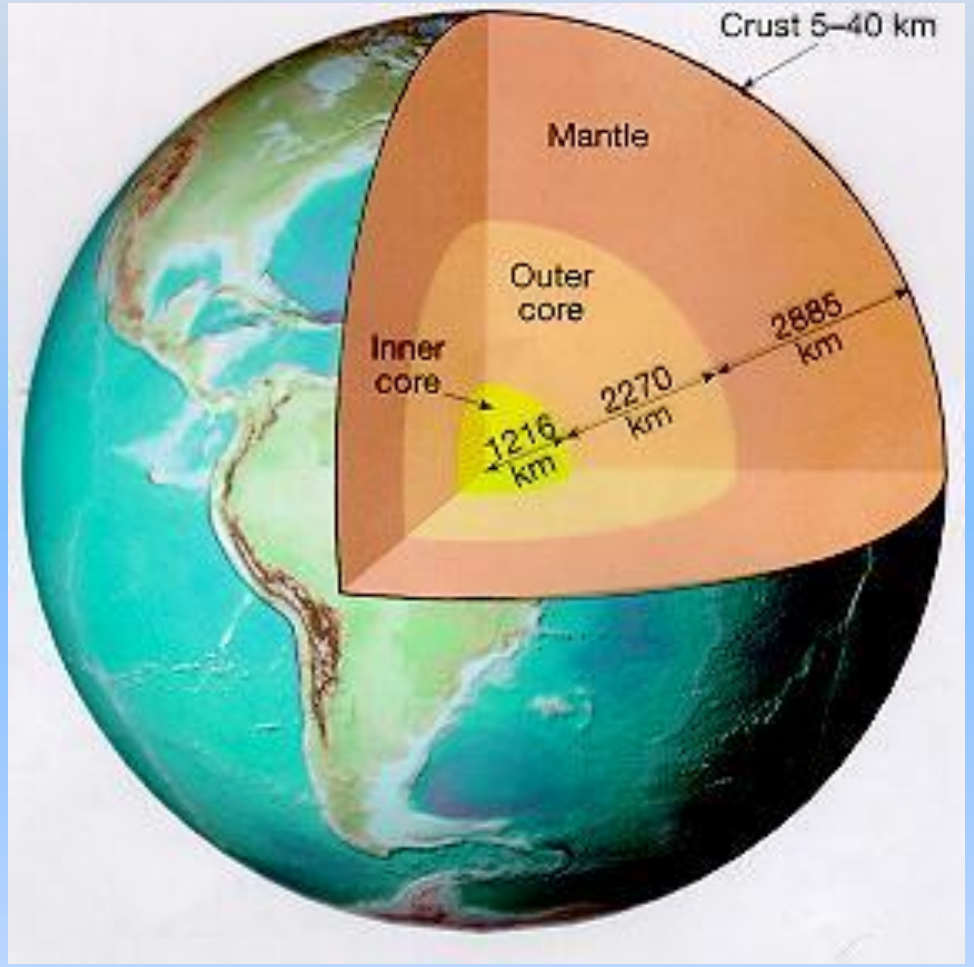


Geosphere

"Earth's Internal Structure"



Earth's interior consists of three major regions that have markedly chemical composition, these three regions are called crust, mantle and core.



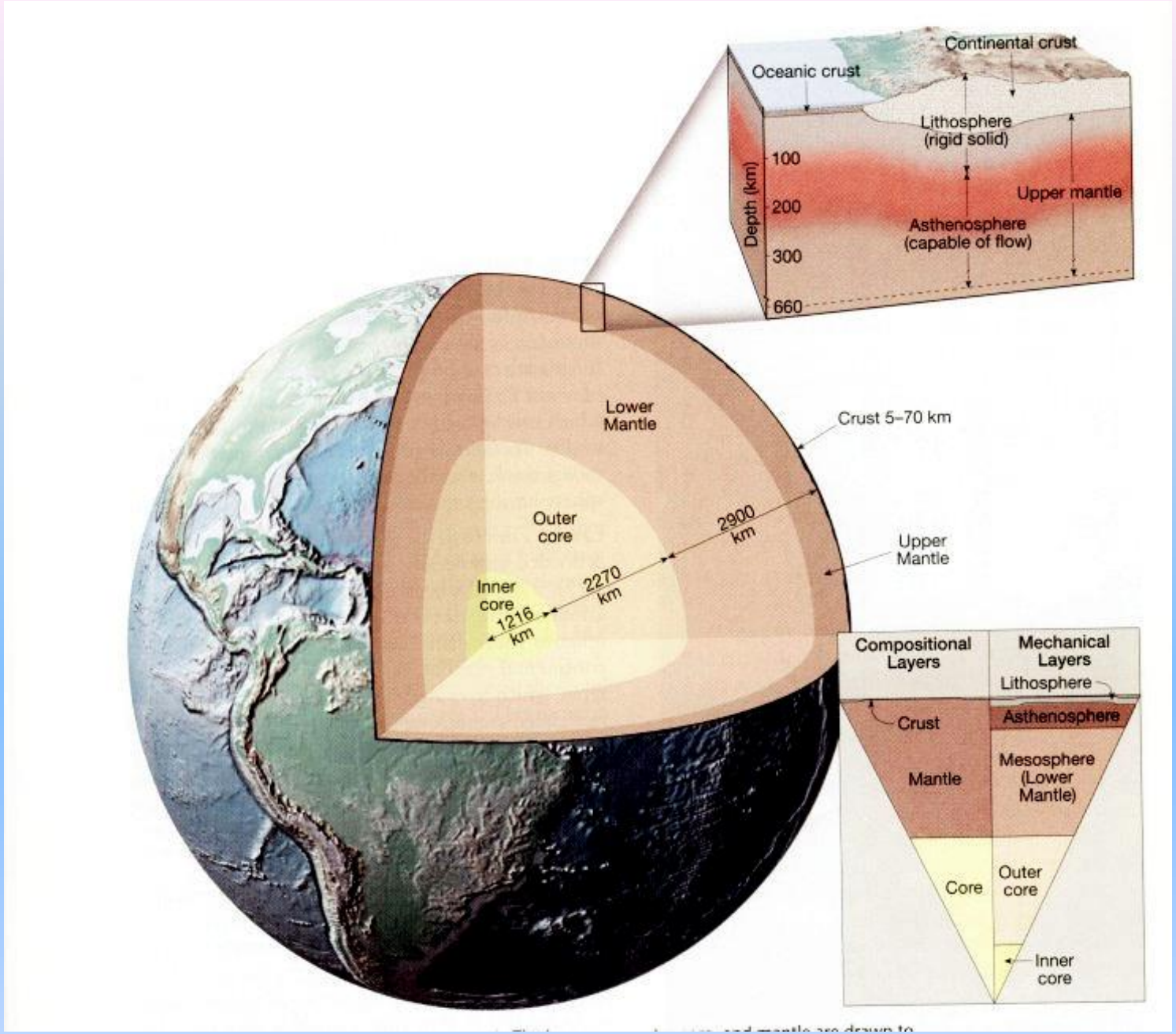
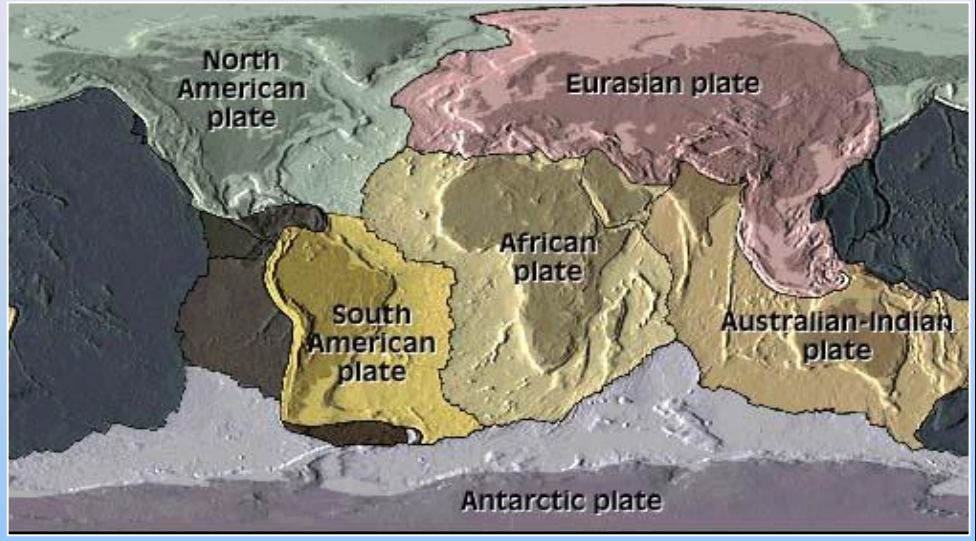
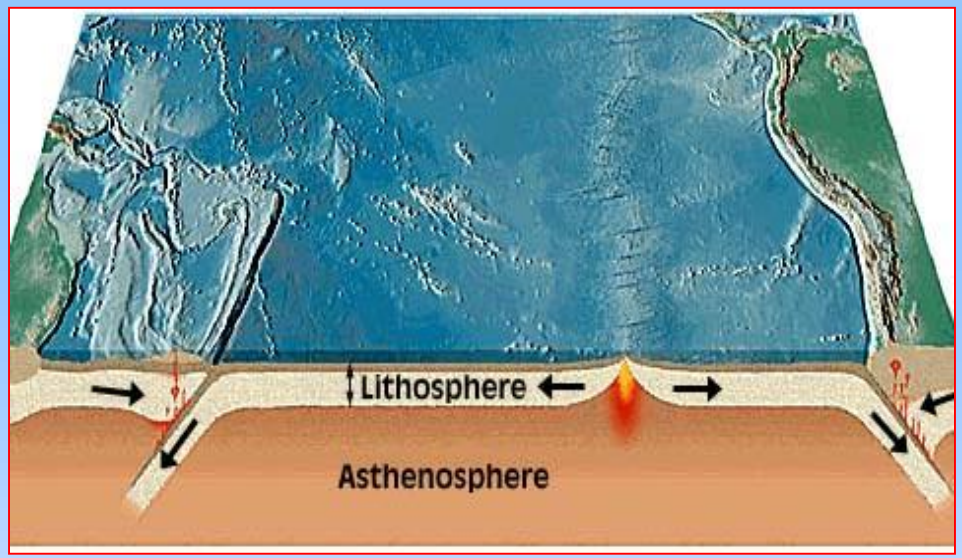

Continental crust
Oceanic crust
Lithosphere
(rigid solid)
Depth (km)
100
200
300
660
Upper mantle
Asthenosphere
(capable of flow)
Lower
Mantle
Crust 5–70 km
Outer
core
2900
km
Upper
Mantle
Inner
core
1216
km
2270
km
Compositional
Layers
Mechanical
Layers
Lithosphere
Crust
Asthenosphere
Mantle
Mesosphere
(Lower
Mantle)
Core
Outer
core
Inner
core

Plate Tectonics

Plate tectonics provide the first comprehensive model of Earth's internal workings. The theory assumes that the lithosphere is broken into numerous segments called plates, which are in motion and are continually changing shape and size. There are seven major plates: North American, South American, Pacific, African, Eurasian, Australian and Antarctic plates plus over a dozen of smaller plates such as the Arabian





Tectonic plates and plate tectonics

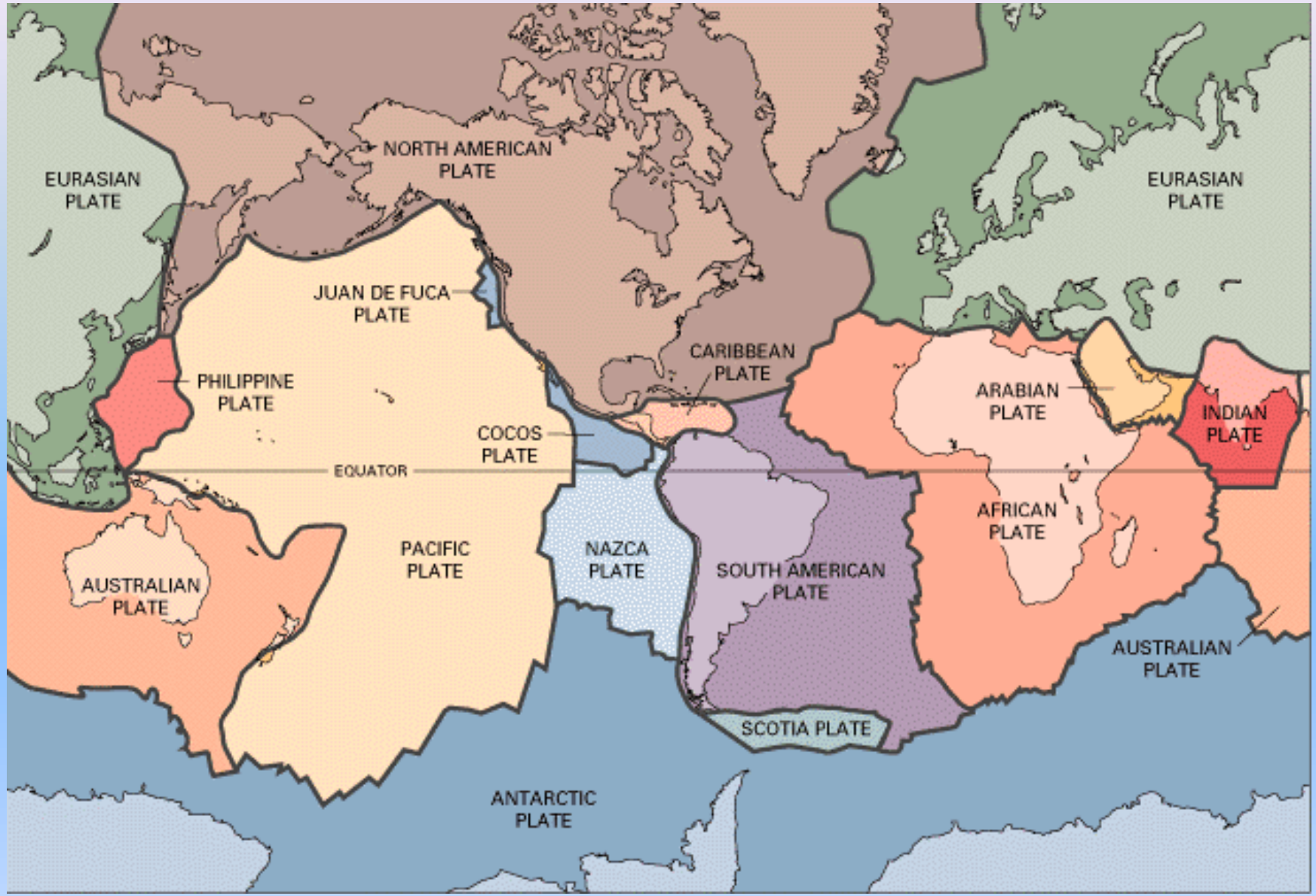
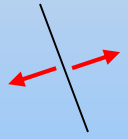


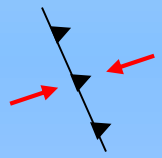
Plate boundaries

3 types

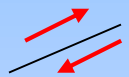
- divergent boundaries

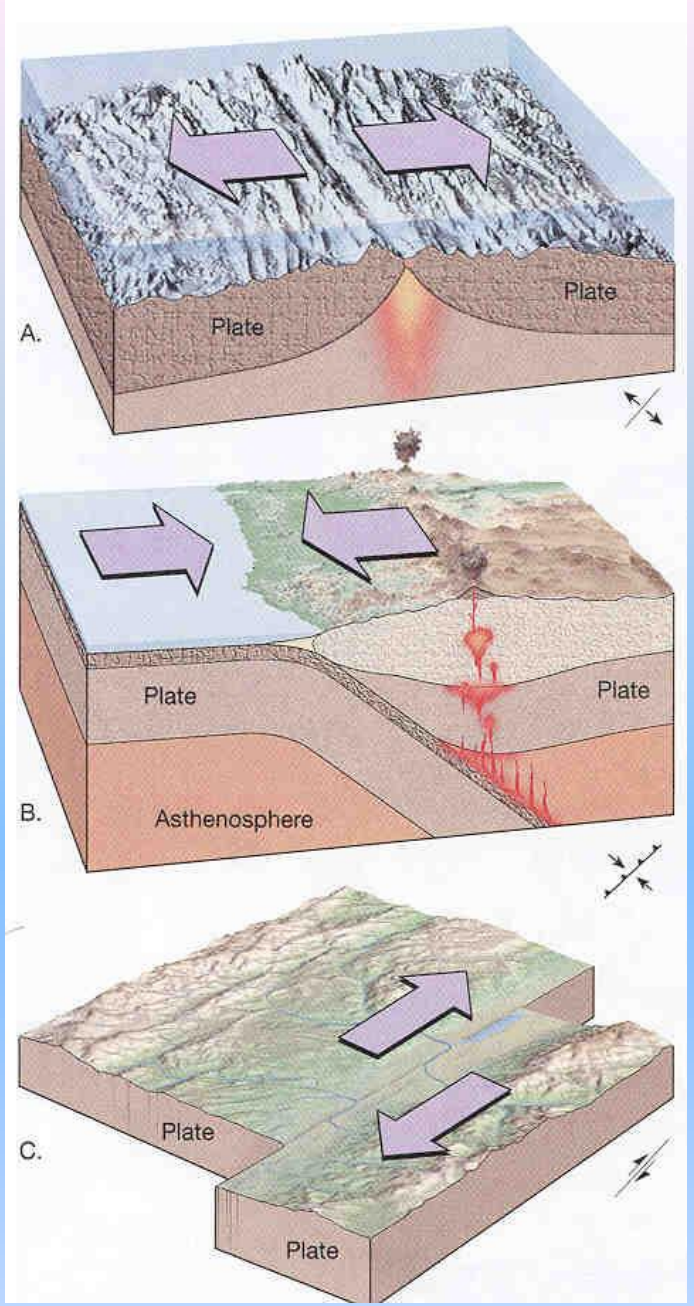


- convergent boundaries



- transform fault boundaries





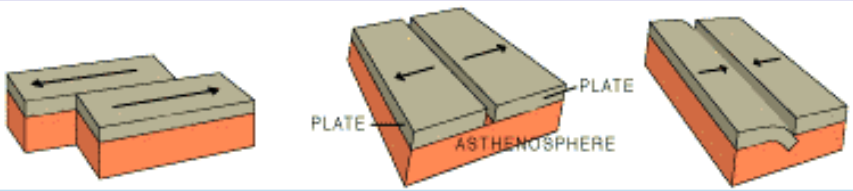
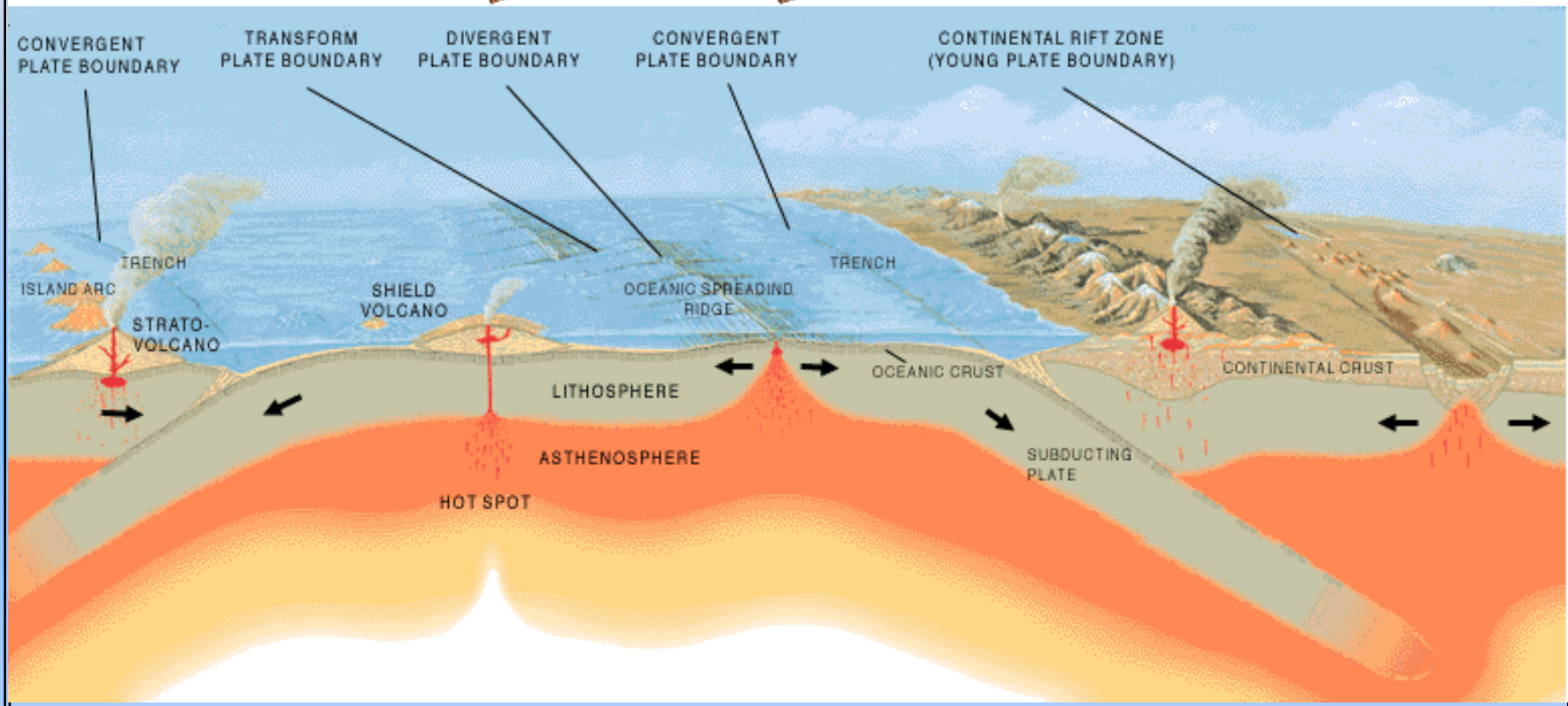
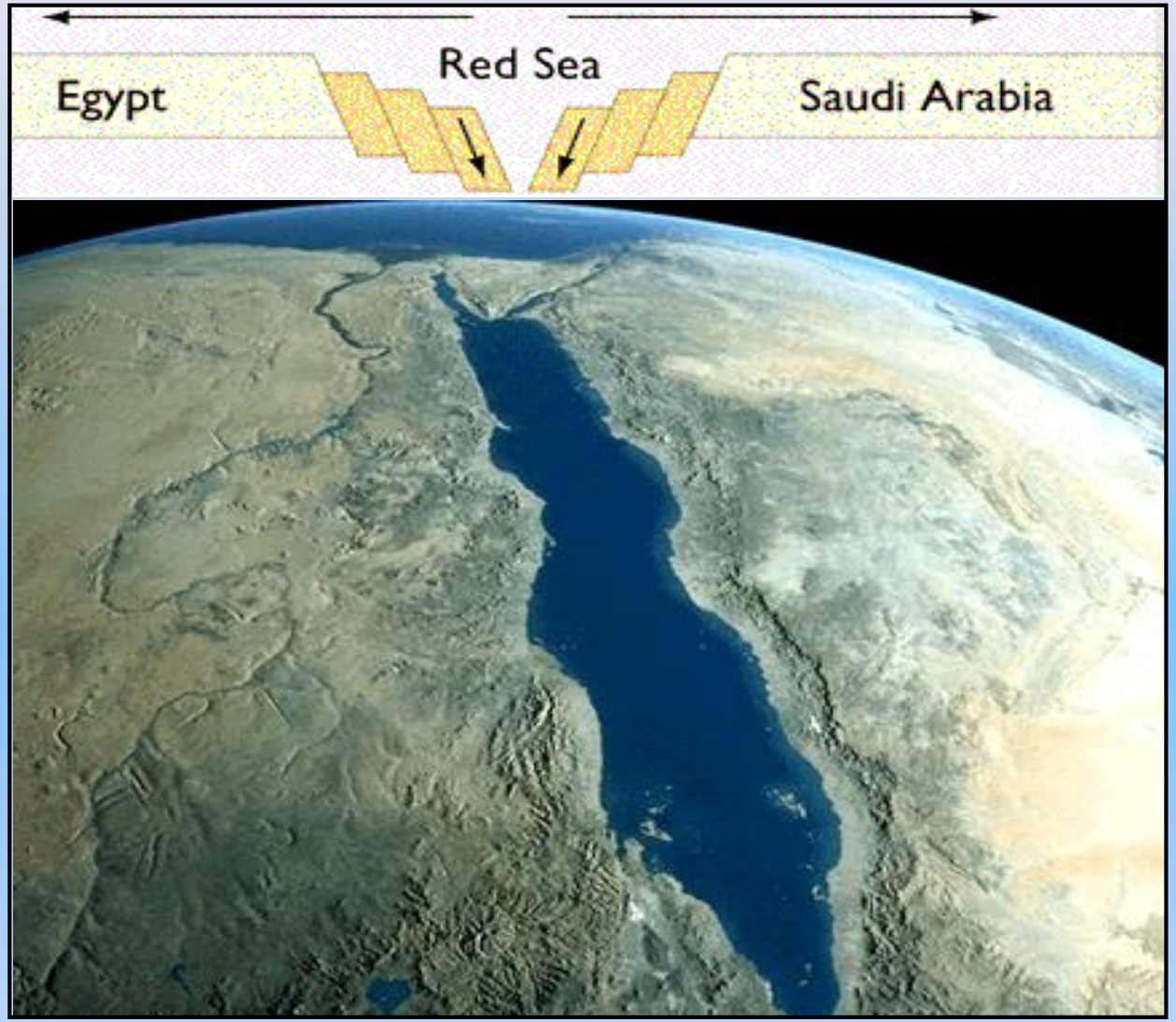


PLATE
PLATE
ASTHENOSPHERE


CONVERGENT PLATE BOUNDARY
TRANSFORM PLATE BOUNDARY
DIVERGENT PLATE BOUNDARY
CONVERGENT PLATE BOUNDARY
CONTINENTAL RIFT ZONE (YOUNG PLATE BOUNDARY)
TRENCH
ISLAND ARC
STRATO-VOLCANO
SHIELD VOLCANO
OCEANIC SPREADING RIDGE
TRENCH
OCEANIC CRUST
CONTINENTAL CRUST
LITHOSPHERE
ASTHENOSPHERE
SUBDUCTING PLATE
HOT SPOT

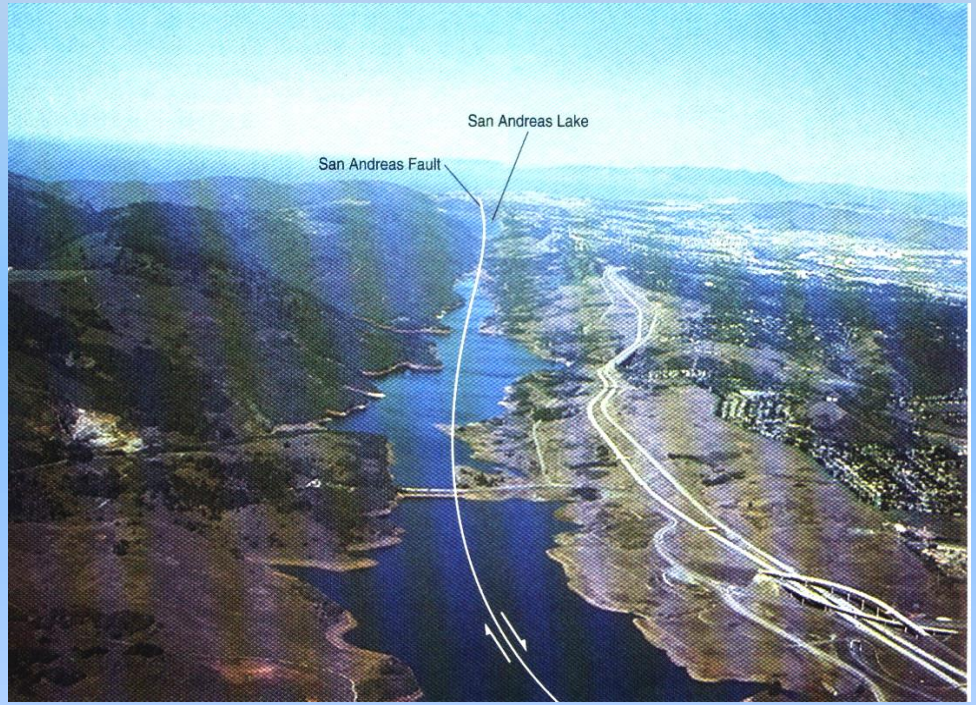
The Red Sea: Birth of an ocean basin



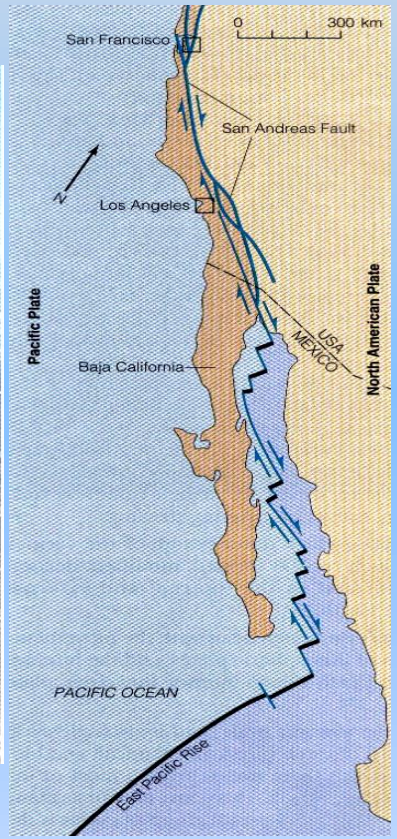
San Andreas Fault, USA

This fault separates the Pacific Plate from the North American Plate. Los Angeles, on the pacific Plate, is moving northward, while San Francisco is moving in the opposite direction, bringing the two cities ever closer together. At an average rate of movement of about 2 centimetres per year, Los Angeles could be a western suburb of San Francisco (or San Francisco an eastern suburb of Los Angeles) in some 25 million years. Earthquakes are produced by sudden movement within the fault system

There the fault zone is hidden by recently built housing tracts. Apparently the builders and residents have chosen to ignore the hazards of living on the nation's most famous fault.



Part of the San Andreas Fault. View northward toward San Francisco. Lakes occupy the fault zone. Hills to the left of the fault are moving northward.



How Geologists Think about Time

Uniformitarianism

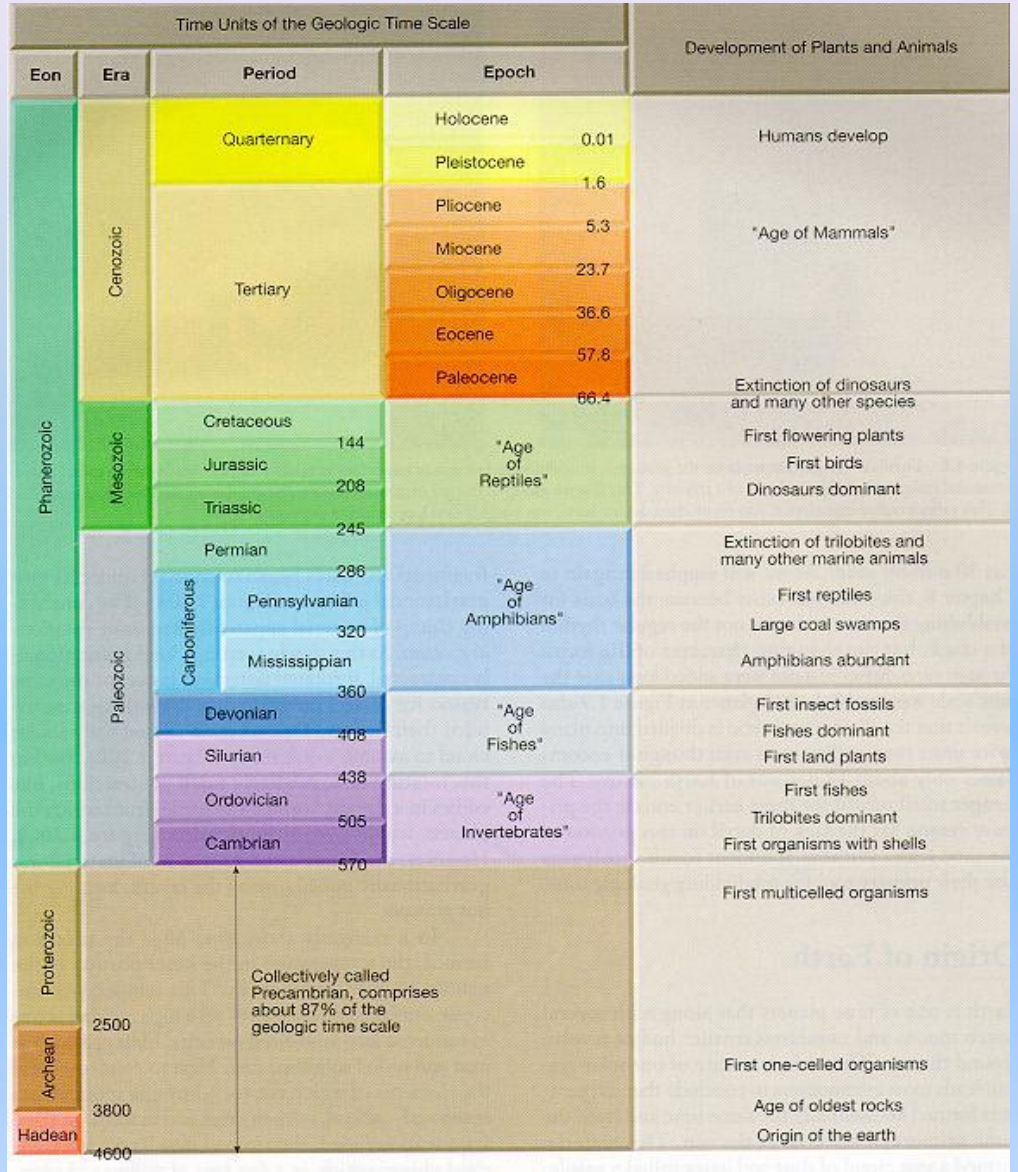
“the present is the key to the past.”

If the geologic processes we observe today are representative of those that occurred in the past, then we can make important inferences about the past by observing Earth processes today.

Geologic time scale

- Life started on the earth about 600 mya, this time is called Phanerozoic.

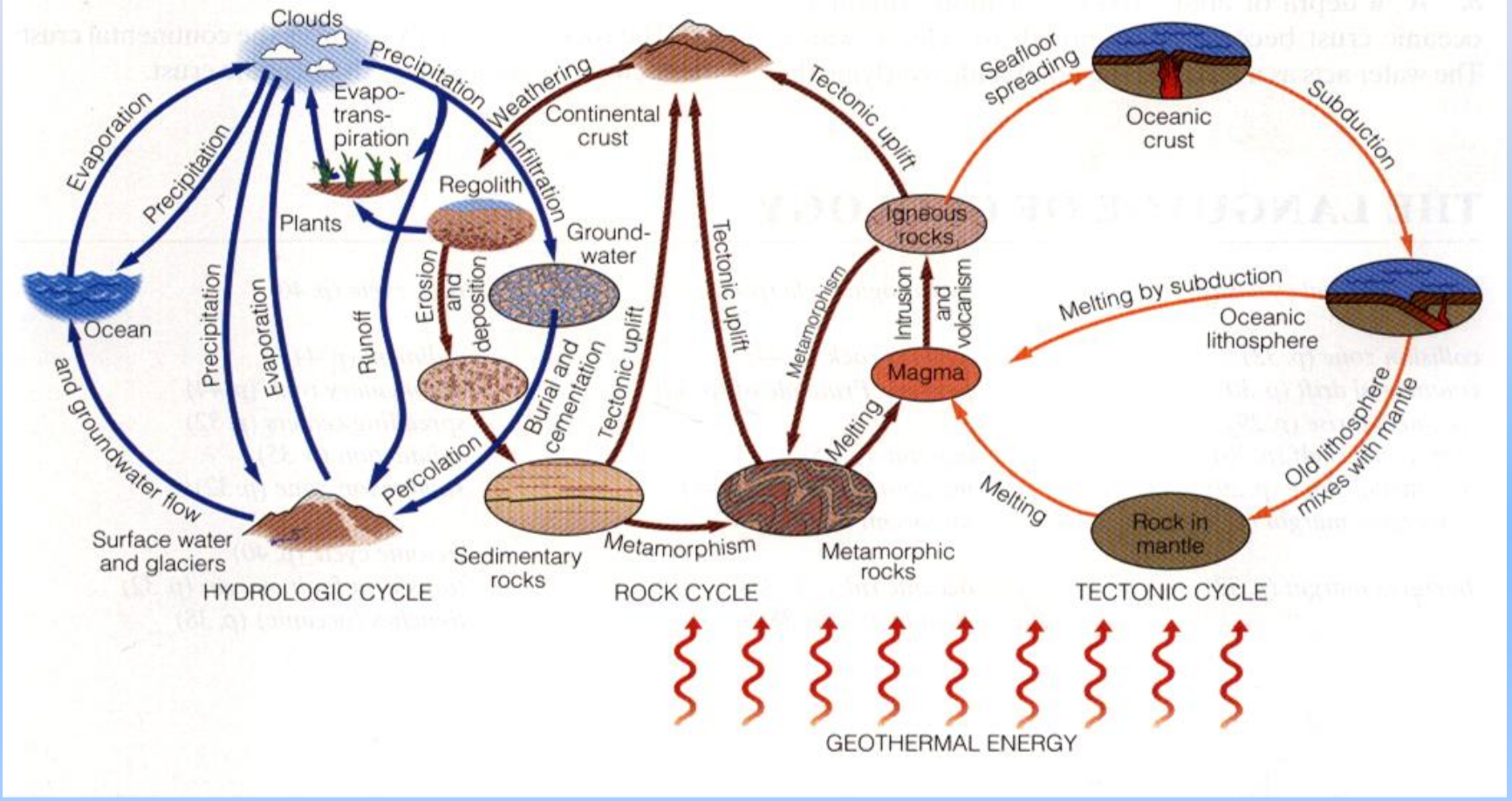
- The other 4000 my are called Precambrian. There was little life in the Precambrian represented by first one-celled and first multi-celled organisms.



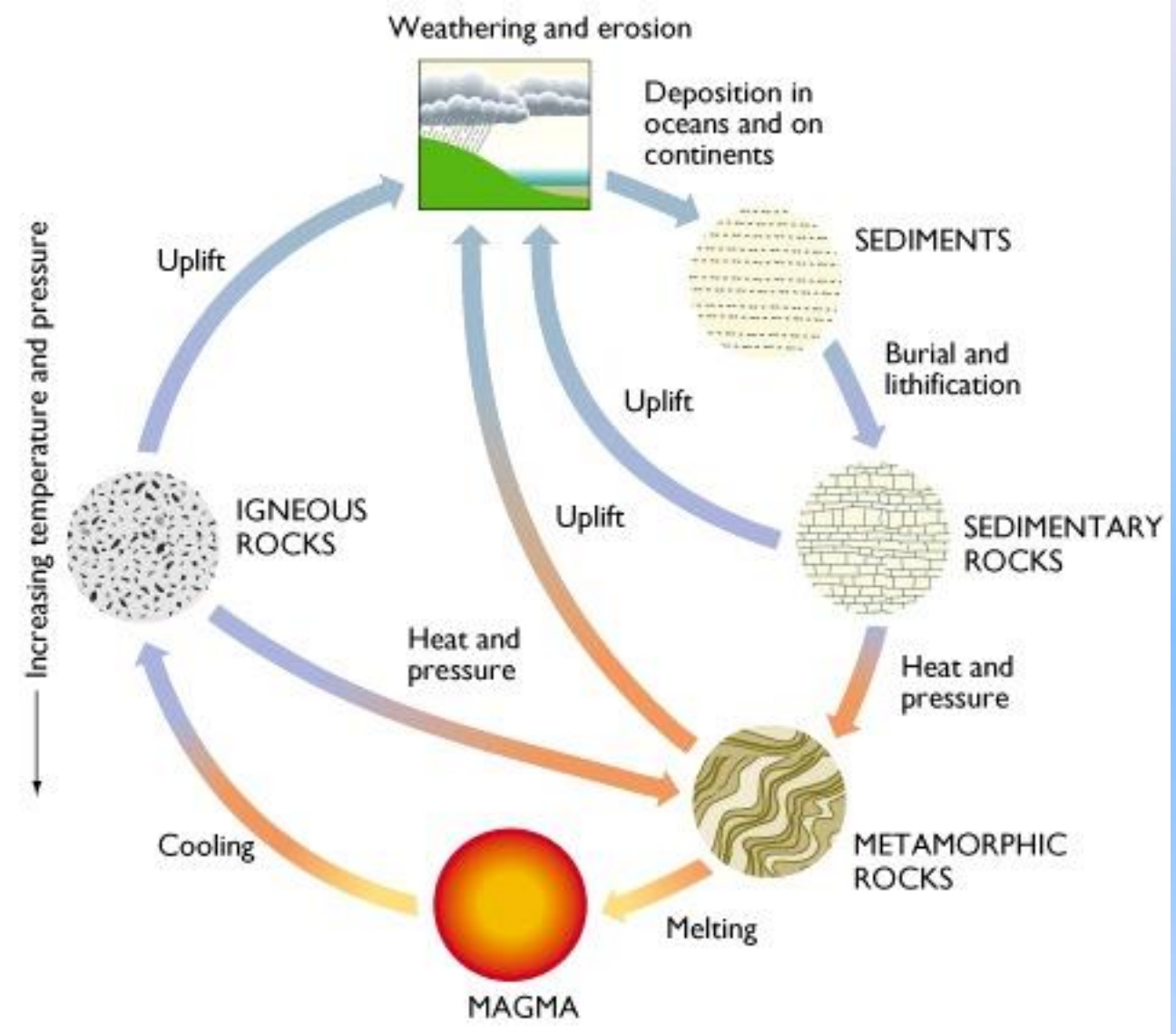
Minerals to Rocks
Major Rock Groups

	IGNEOUS	SEDIMENTARY	METAMORPHIC
			
Source of material	Melting of rocks in hot, deep crust and upper mantle	Weathering and erosion of rocks exposed at surface	Rocks under high temperatures and pressures in deep crust and upper mantle
Rock-forming process	Crystallization (solidification of magma)	Deposition, burial, and lithification	Recrystallization in solid state of new minerals

Geologic Cycles



The Rock Cycle



- **Rocks & Minerals**
  - **Mineral Classifications**
  - **Mineral Resource Protection**
  - **Mining & its Impacts**

Minerals and Rocks

The minerals are the building blocks of rocks

Definition of a rock:

It is any solid mass of minerals or mineral like matter that occurs naturally as part of our planet.

Rocks and Minerals

What is a mineral? What is a rock?

Mineral: An inorganic, naturally-occurring, crystalline solid, with a specific chemical composition.

Examples: quartz (SiO_2), calcite ($CaCO_3$), halite (NaCl), olivine ($(Mg,Fe)_2SiO_4$)

Rock: An aggregate of minerals.

Minerals vs. Non-minerals

Mineral	NATURAL Iron ore (hematite)	SOLID Sand (quartz)	INORGANIC Rock salt (halite)
Nonmineral	ARTIFICIAL Cast iron (metallic iron)	LIQUID Seawater (H_2O + salts)	ORGANIC Vegetation (cellulose)
		GAS Air (oxygen)	

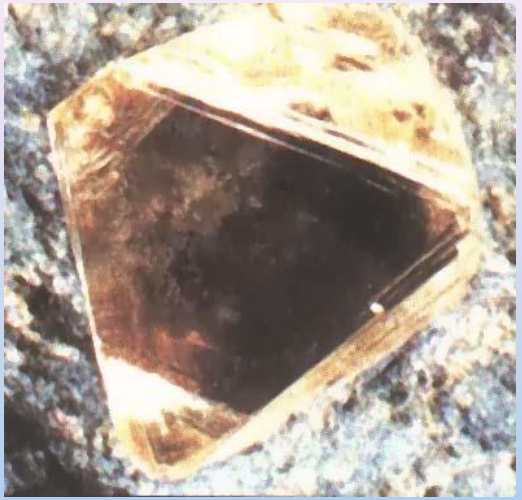
Examples:

* Diamond is a mineral, but synthetic diamond is not a mineral.

* Graphite is a mineral, but coal is not a mineral.

* Quartz is a mineral, but opal is not a mineral because it lacks an orderly internal structure.

* Oil is not a mineral because it is organic in origin.

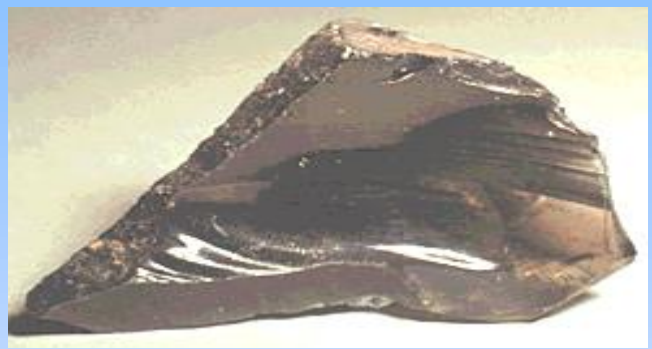


Classification of rocks

1- Monominerallic rock: a rock composed of one mineral. E.g. limestone is composed of the mineral calcite.

2- Polymineralic rock: a rock composed of several minerals (e.g. granite is composed mainly of three minerals called quartz, feldspar and hornblende).

3- Nonminerallic rock: a rock composed on nonminerallic matter. (e.g. Obsidian and pumice (noncrystalline glassy substances).



Physical properties of minerals

The 4000 minerals discovered up till now are characterized each by certain physical properties which allow us to distinguish each mineral from the other. These physical properties are:

1- Crystal form: A crystal is a solid substance that has regular faces resulting from an orderly arrangement of atoms.

- Minerals form crystals with well-developed faces when they find space for crystal growth.

- When there is no space for crystal growth, they form intergrown masses of crystals without a definite crystal form.

Quartz (Hexagonal system)

2- Luster

It is the appearance or quality of light reflected from the surface of a mineral.

- **Metallic Luster:** minerals that show the appearance of metals.

- **Nonmetallic luster:** minerals that show other nonmetallic appearance. This may be vitreous (glassy, pearly, silky, resinous and earthy (dull).

- **Submetallic luster:** minerals that appear partially metallic in luster.

Metallic luster

Nonmetallic luster

Color

- Color is a diagnostic property for identifying minerals. Sulfur for example has a yellow color, and malachite has a bright green color.

-In many cases, a mineral can have several colors due to the presence of impurities in its crystalline structure.

Ex. quartz is usually white but it has also other colors including pink, purple and even black.

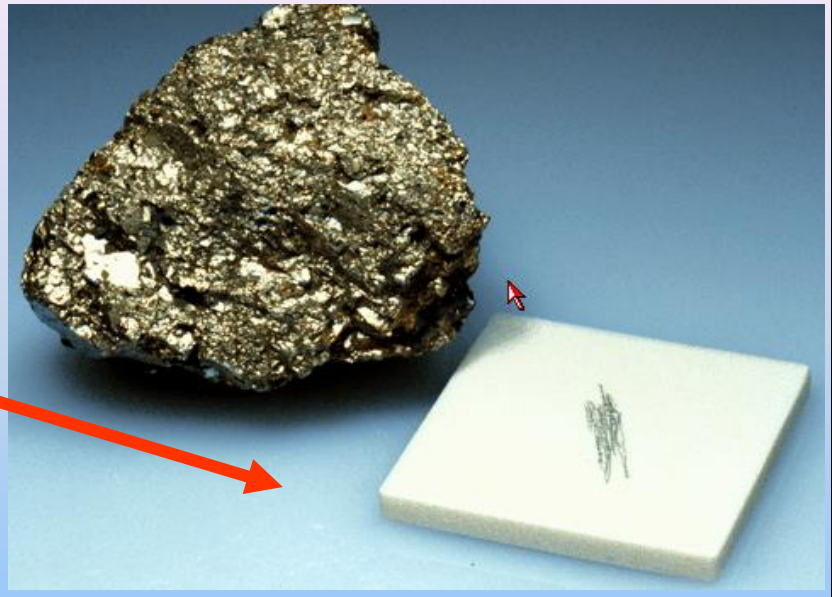
Streak

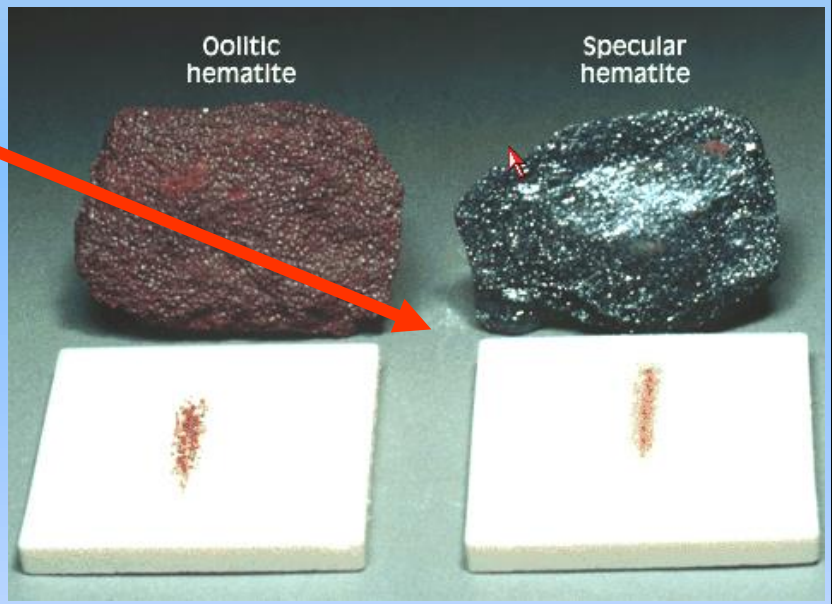
- It is the color of the powder produced by rubbing the mineral across a streak plate made of unglazed porcelain.

-The streak is not necessary to be the same as the color of the mineral. For example some black minerals have a brown streak.

-The streak of mineral is the same whatever the color of the minerals.

-minerals with metallic luster have darker and denser streak than minerals with non metallic luster



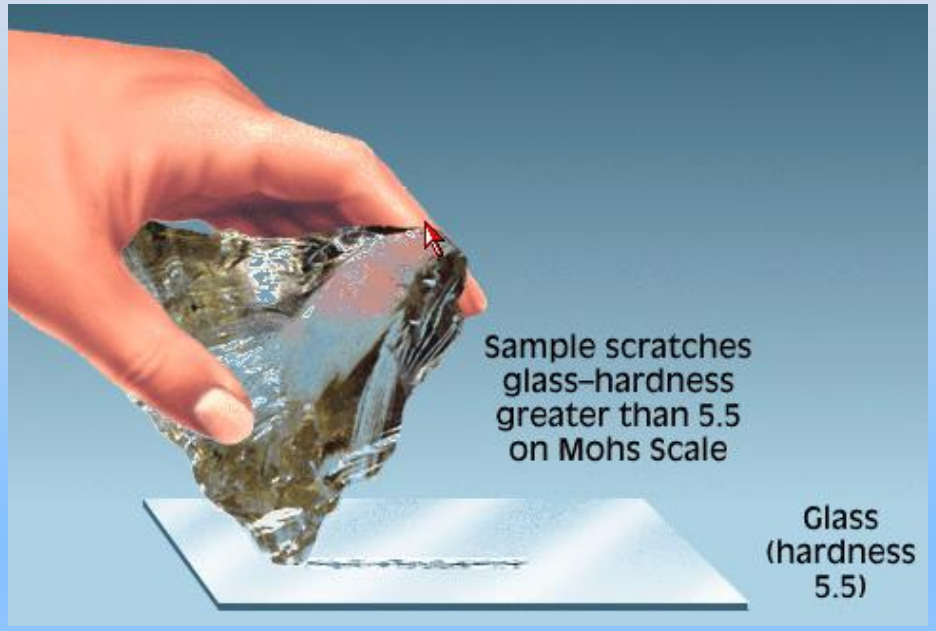


Hardness

- It is the degree of mineral resistance to scratching.

- It is determined by rubbing a mineral with unknown hardness against one of known hardness or vice versa.

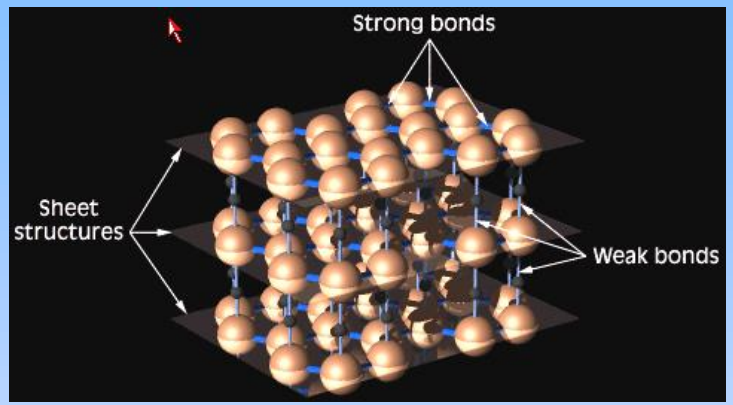
- Minerals With known hardness belong to Mohs scale of Hardness.

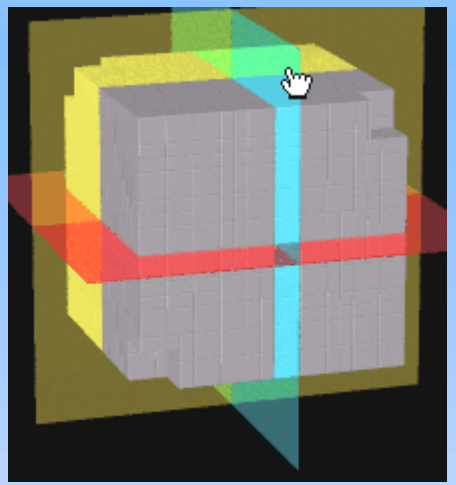


Cleavage

It is the tendency of a mineral to break along planes of weak bonding.

Some minerals have one cleavage plane such as micas, some have four such as fluorite or three such as calcite. Quartz on the other hand has no cleavage.



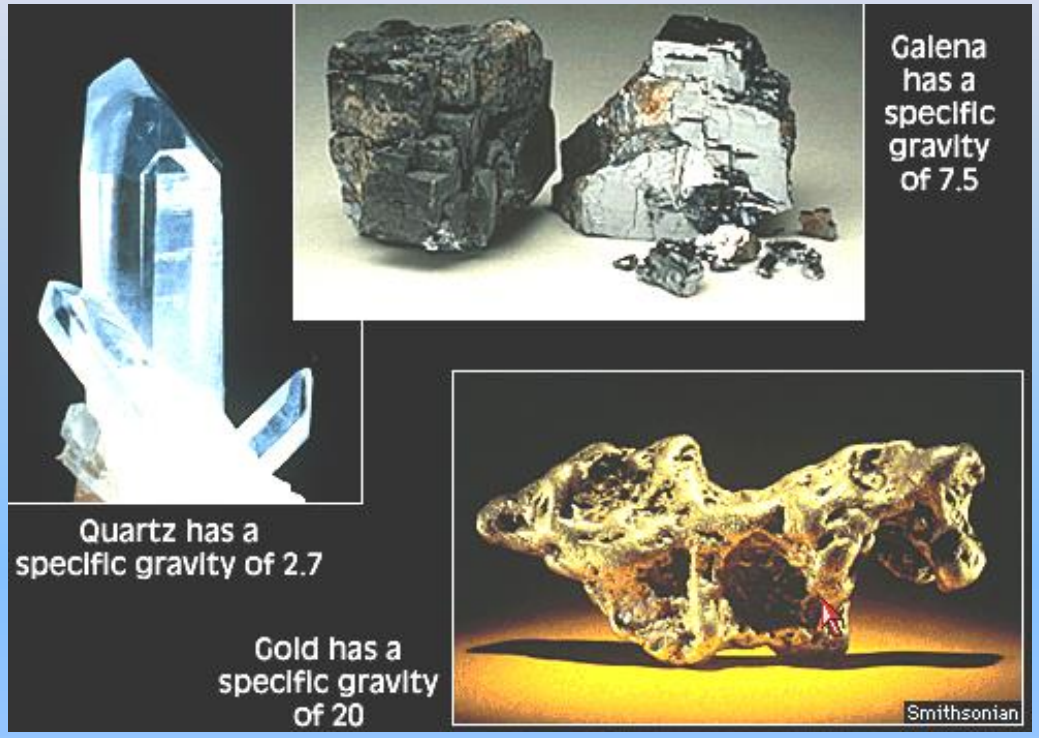


Fracture

- It is the shape of minerals that don't have cleavage when broken.
- Some minerals break into smooth curved surface like broken glass this is called conchoidal fracture, others break into splinters or fibers but most minerals fracture irregularly.

Specific gravity

It is a number representing the ratio of the weight of a mineral to the weight of an equal volume of water.
For example if a mineral weighs three times as much as an equal volume of water its specific gravity is 3.



Other properties of minerals

1-Taste: halite has a salty taste.
2-Smell: sulfur streak smells like rotten eggs.
3-Elasticity: mica sheets bend easily and elastically snap back.
4-Malleability: copper & gold are malleable and can easily shape.
5-Feel: Talc feels soapy and graphite feels greasy.

2

1

3

5

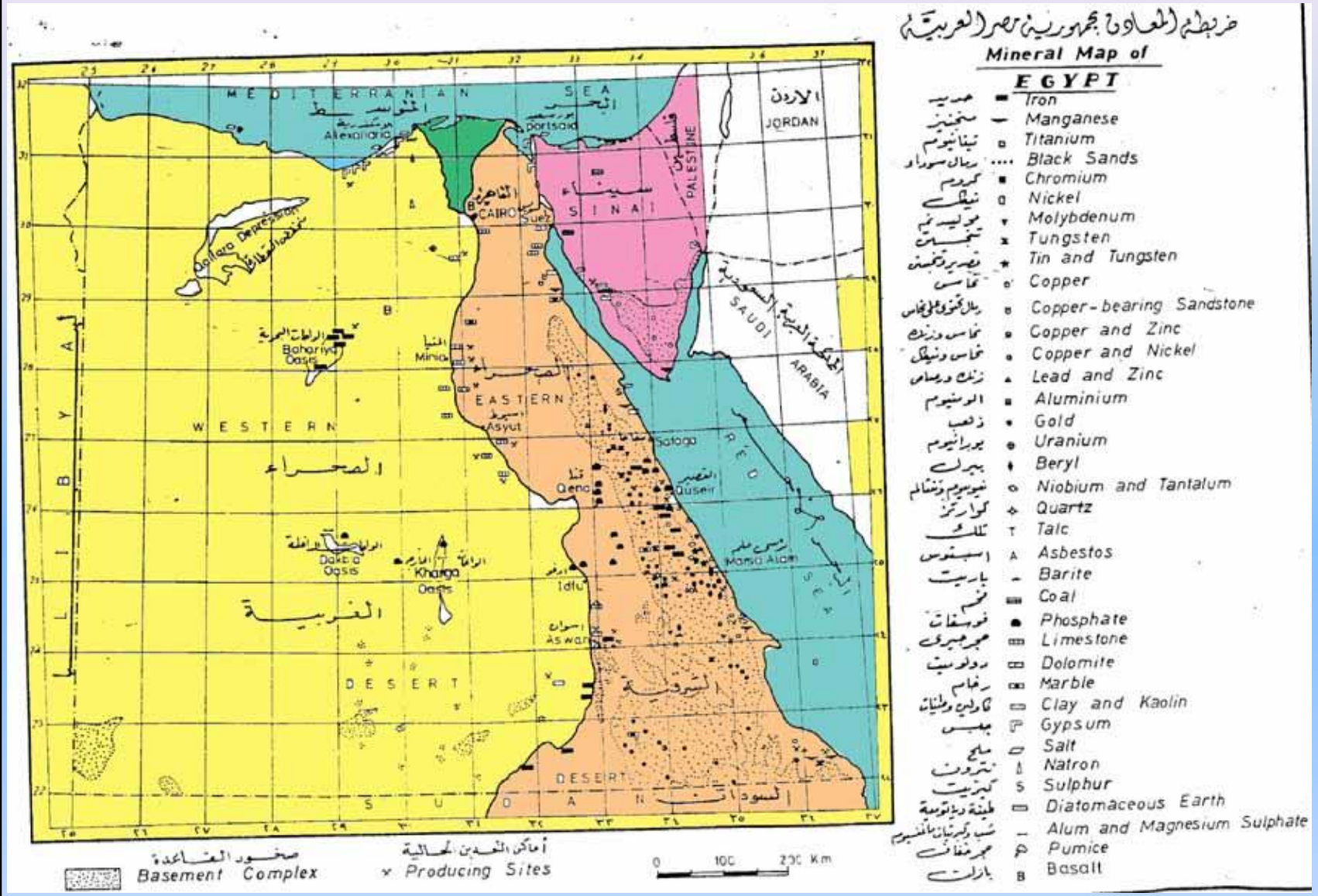
6- Magnetism: a magnet picks up Magnetite because it has high iron content.

7- Double refraction: when a transparent calcite is placed over a written word, the letters appear twice.

8- Chemical reactions to HCl: carbonates such as calcite effervesce (fizz) with HCl.

9- **Transparency:** some minerals are transparent; others are translucent whereas others are opaque.

Metallogenic map of Egypt

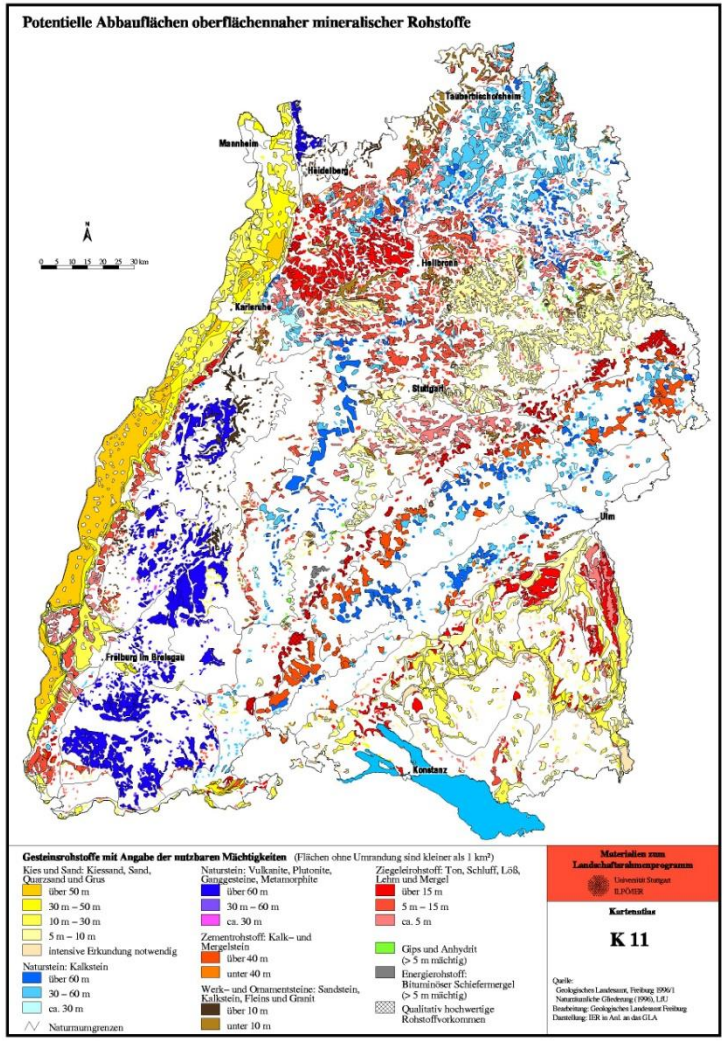


خريطة المعادن لجمهورية مصر العربية

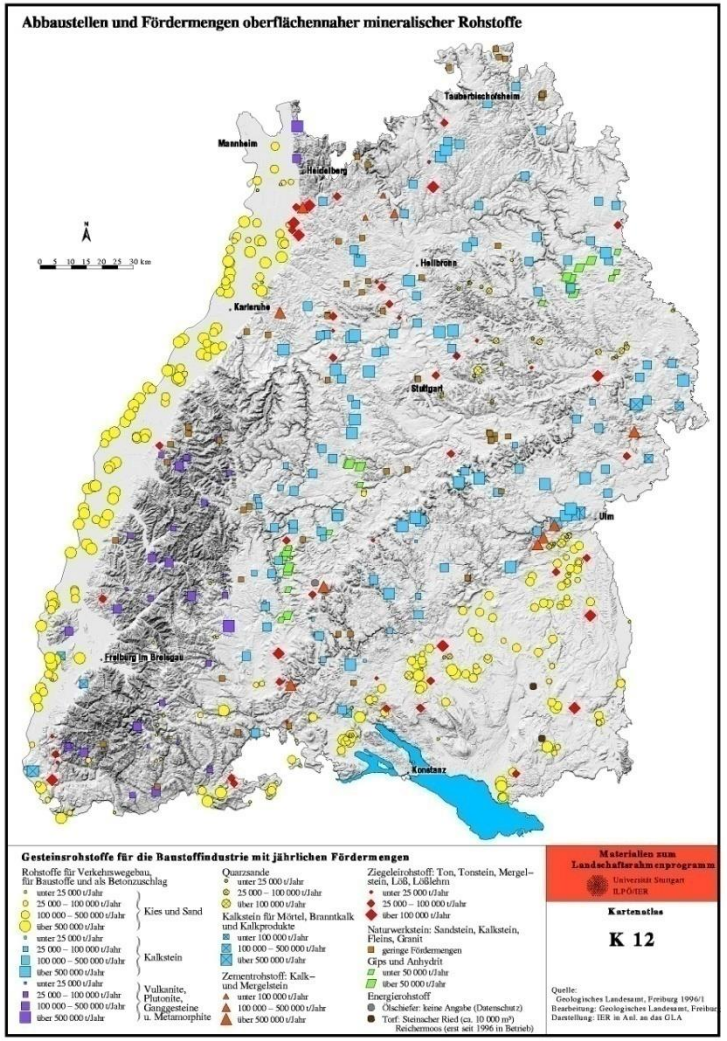
Mineral Map of EGYPT

- Iron
- Manganese
- Titanium
- Black Sands
- Chromium
- Nickel
- Molybdenum
- Tungsten
- Tin and Tungsten
- Copper
- Copper-bearing Sandstone
- Copper and Zinc
- Copper and Nickel
- Lead and Zinc
- Aluminium
- Gold
- Uranium
- Beryl
- Niobium and Tantalum
- Quartz
- Talc
- Asbestos
- Barite
- Coal
- Phosphate
- Limestone
- Dolomite
- Marble
- Clay and Kaolin
- Gypsum
- Salt
- Natron
- Sulphur
- Diatomaceous Earth
- Alum and Magnesium Sulphate
- Pumice
- Basalt

Mineral resources / State level

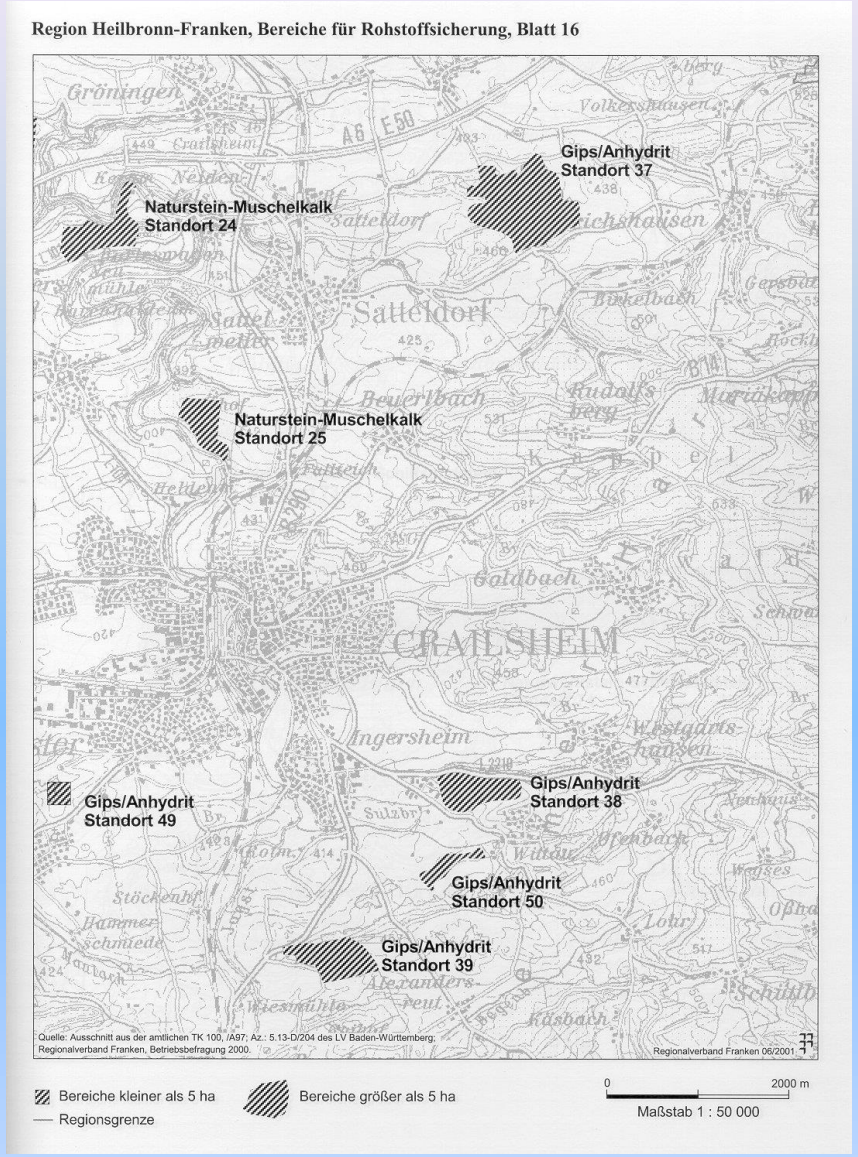


Potential extraction areas



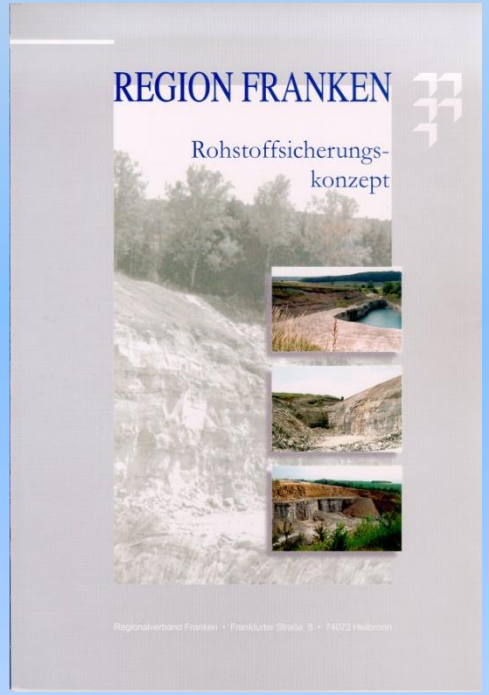
Mining areas and output

Priority areas mineral resource protection



Defined in the regional development plan,

to be considered in the city master plan



Status and statistics, mineral resources in the Region Heilbronn

Administrative status of protection and availability of mineral resources

Exploitation reserves and duration in the Region Heilbronn

Exploitation volume per year 7 mio t

effective / updated **exploitation reserves / duration**	**amount mio t**	**years**
approved reserves	90 – 100	12 – 14
planned reserves	110 – 120	15 – 17
thereof:		
requested exploitation areas	18 – 19	2 – 3
total	200 – 220	27 - 31

- - data without „areas of interest“ --

Source: Regionalverband Franken, 2001

Mining & its environmental impact

Outline

1. **Types of Mining (and why we use them)**
2. **Beneficiation**
3. **Smelting**
4. **Environmental Concerns**

What determines the type of mining?

- **Underground v.s. Surface Mining v.s. Solution**
- **Depth of below surface**
- **Size of the ore body**
- **Shape of the ore body**
- **Grade**
- **Type of Ore**

What are the types of mining?

- Surface
  - Strip
  - Open Pit
  - Placers--Dredging
- Underground
- Solution

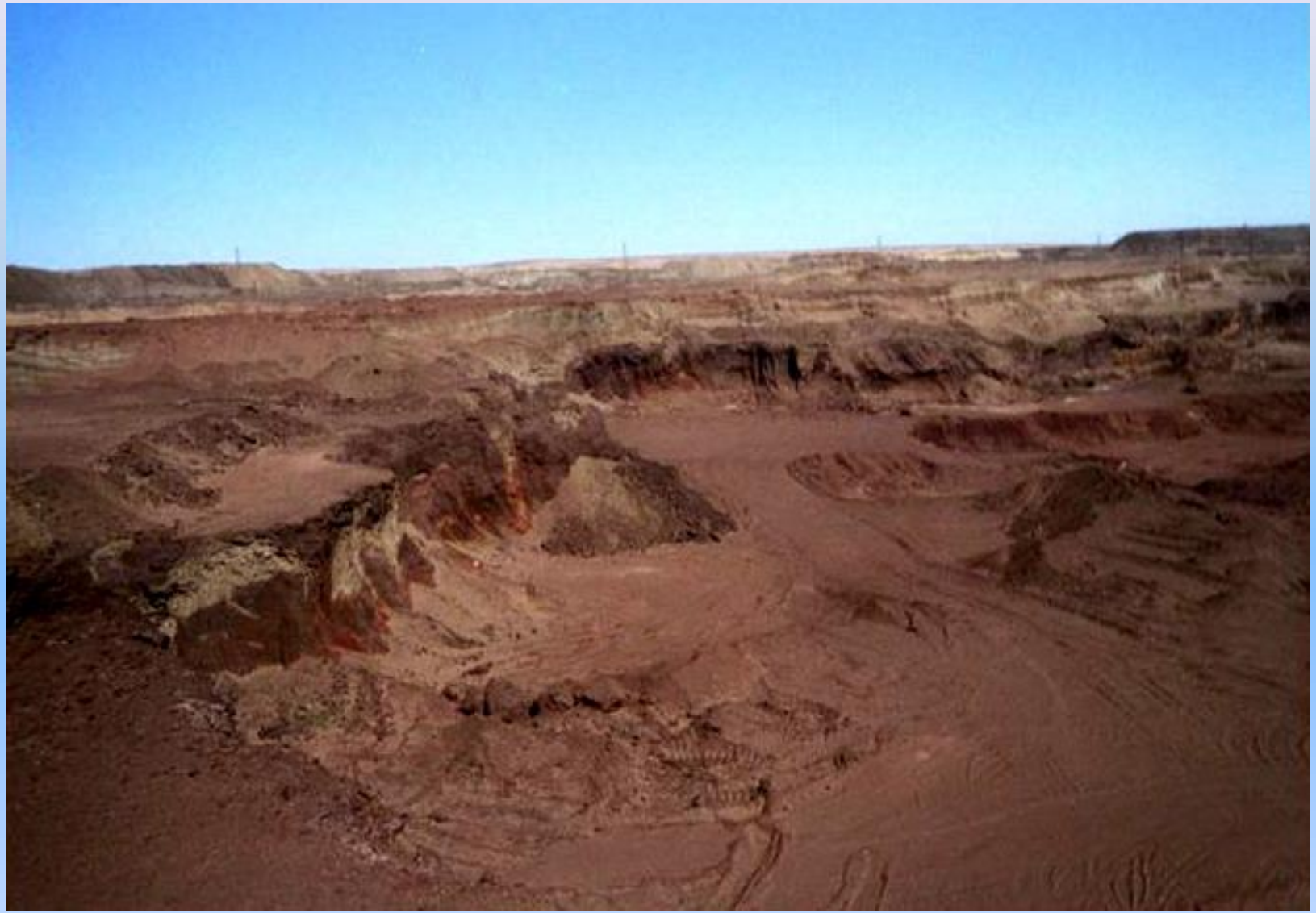
When do you use Surface Mining?

- **Large tonnage**
- **High rates of production**
- **Overburden (including rock) is thin**

Strip Mining of Coal

Kansas Geological Survey

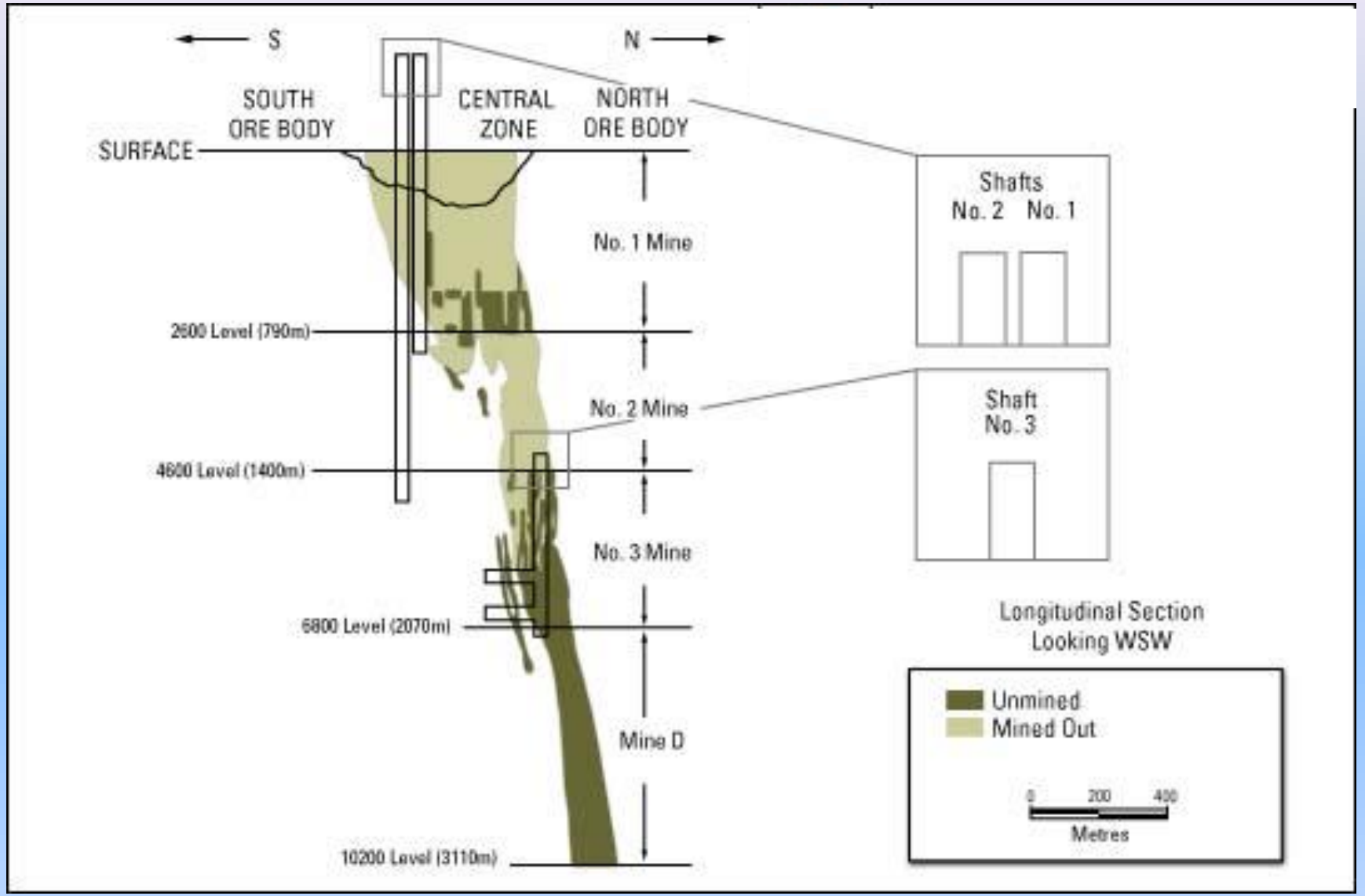
Open Pit Mining
(Bahariya Oasis,Egypt, Iron ore)



When do we mine underground?

- The ore deposit is deep
- Ore body is steep
- Grade is high enough to cover costs

Shape of Ore Body

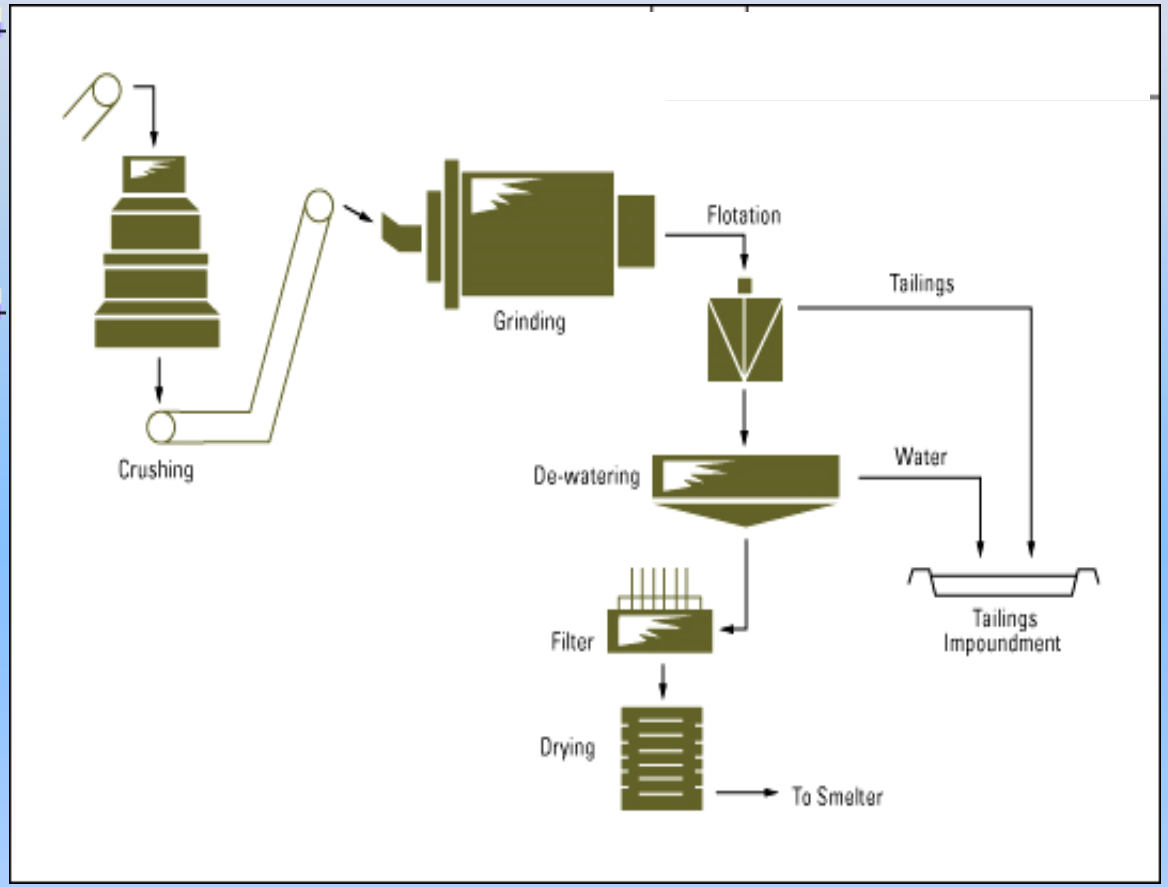


Underground Mining

(Fawakhir Gold mine, Egypt)

What does it entail?

- Crushing and Grinding
- Ball mill or rod mill
- Separation
- Density (e.g. diamonds)
- Magnetic properties
- Electric properties
- Surface properties



Refining the Ore

Smelting

removes the metal from the ore mineral by a variety of ways

Heap Leaching

removes metal from the ore by solution

Beneficiation

Means of separation of ore mineral from waste material (or gangue minerals) also known as Liberation

Heap Leaching

(e.g. Hamash gold mine, Eastern desert,Egypt)

- **In this process, typically done for Au, the ore is not ground, but rather, crushed and piled on the surface.**
- **Weak solutions of NaCN (0.05%) percolate through the material leaching out the desired metals.**
- **The solutions are collected and the metals are precipitated**

Potential Environmental Problems!

- Mining operation itself
- Disposal of a large amount of rock and waste
- Noise
- Dust
- Beneficiation
- Smelting and refining

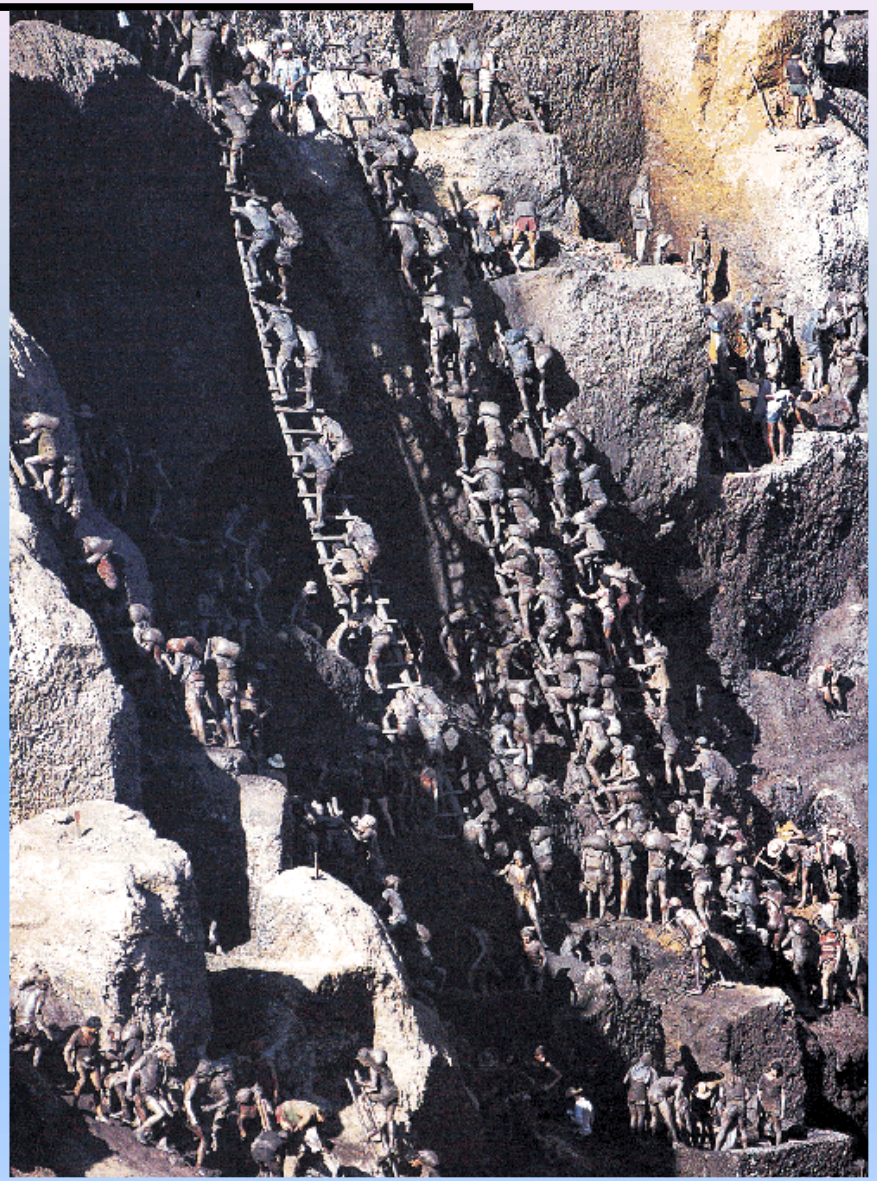
Problems with open pits

- Very large holes
- Pit slopes steep and not stable. Cannot be maintained
- May fill with water
- Strip coal mines –loss of top soil in past
- Now smoothed out and top soil added

Impacts of mining mineral resources

Mining is one of the most dangerous activities. There are other negative impacts of mining which, to some extent, can be mitigated.

Bingham mine, Utah, the largest open pit mine in the World



Miners at Serra Pellada gold mine, Brazil

Impacts of mining mineral resources: surface mines

Surface mines disrupt the original topography and may greatly disturb the ecology of an area (by devegetation, use of machinery, blasting, reworking of the soil, etc.).

Subsidence from Pb-Zn mining

Acid and open pits

Berkley Pit


Berkeley Pit
N

From Underground

- Acid Mine Drainage
- Fe-S minerals in coal
- Sulphide deposits
- Acidic streams can pick up heavy elements and transport them

Impacts of mining mineral resources: abandoned mines

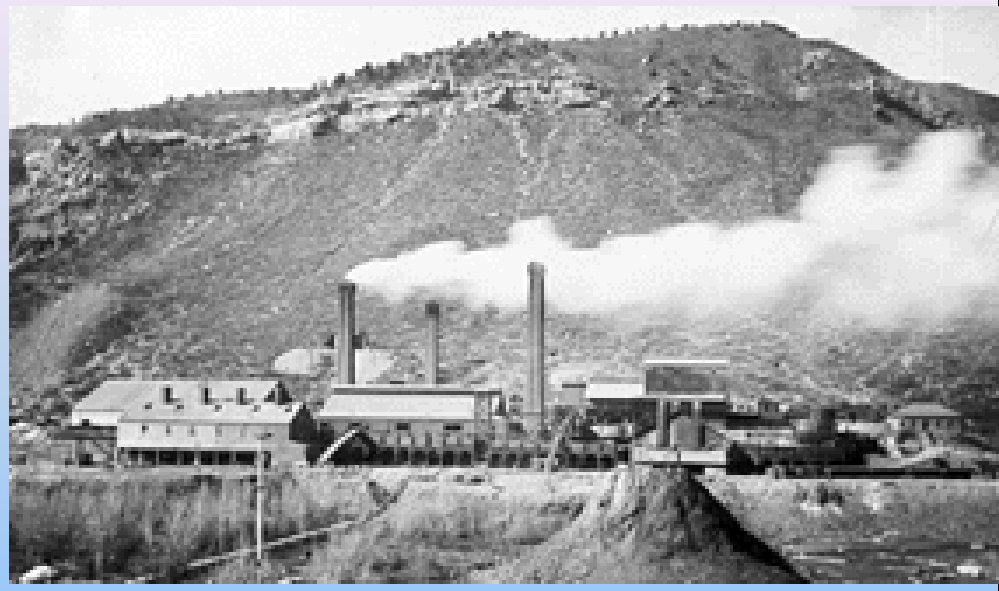
Acid mine drainage from abandoned mine

Ungraded benches, TN

Impacts of mining mineral resources: extraction methods

Improper *smelting* of ore to extract metals releases toxic heavy metals and sulfur in the atmosphere. Sulfur is converted to sulfuric acid and produces **Acid Rain**.

Nowadays, smelting practices are rigorously controlled to reduce toxic emissions.



Smelting in the 1890's, CA

Many metal ores are sulfide minerals.
Extraction results in release of sulfur

Dead trees from acid rain

Problems with Smelting/Roasting

- Air: SO_2 and CO_2 and particulate matter
- CN (Au); NaOH and F (Al); solvents (electro twinning); heavy metals; oil and grease

Disposal of Waste Rock

- More problematic for open pit than underground
- Waste rock piles have steep angle of repose and thus may not be stable
- Bingham in its hay day produced 400,000 tons of waste rock per DAY!

- **Geological Resources**
  - **Resource Consumption & GNP**
  - **Energy Resources**

GEOLOGIC RESOURCES

Resources

Resources are all those things that are necessary or important to human life and civilization, that have some value to individuals and/or to society.

All Earth resources have been generated by one or more geologic processes.

These processes are forming, modifying, or destroying some Earth resources.

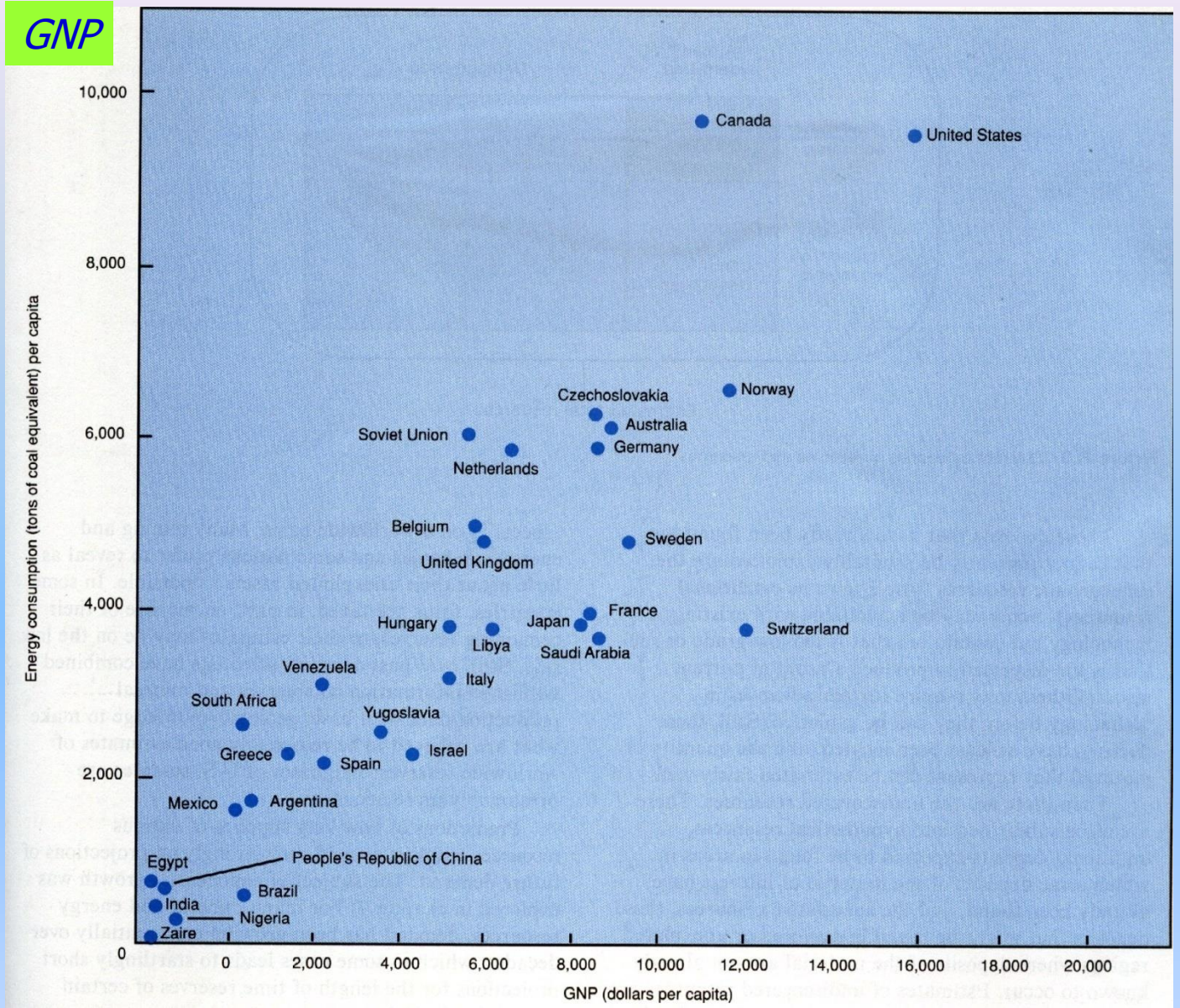
Mineral and energy resources from the crust are the raw materials from which the products used by society are made

RESOURCES, PEOPLE, AND STANDARDS OF LIVING

- ***The more people on the earth, the more water consumed, the more fuel burned, the more minerals used, and so on. .***
- ***The rates of resource use are increasing even faster than the population***
- ***Gross National product (GNP) reflects the level of technological development and standard of living.***
- ***A positive correlation between GNP and energy consumption: The more energy consumed, the higher the value of goods and services produced. and generally, the higher the level of technological development as well***

RESOURCES, PEOPLE, AND STANDARDS OF LIVING

GNP



GEOLOGIC RESOURCES

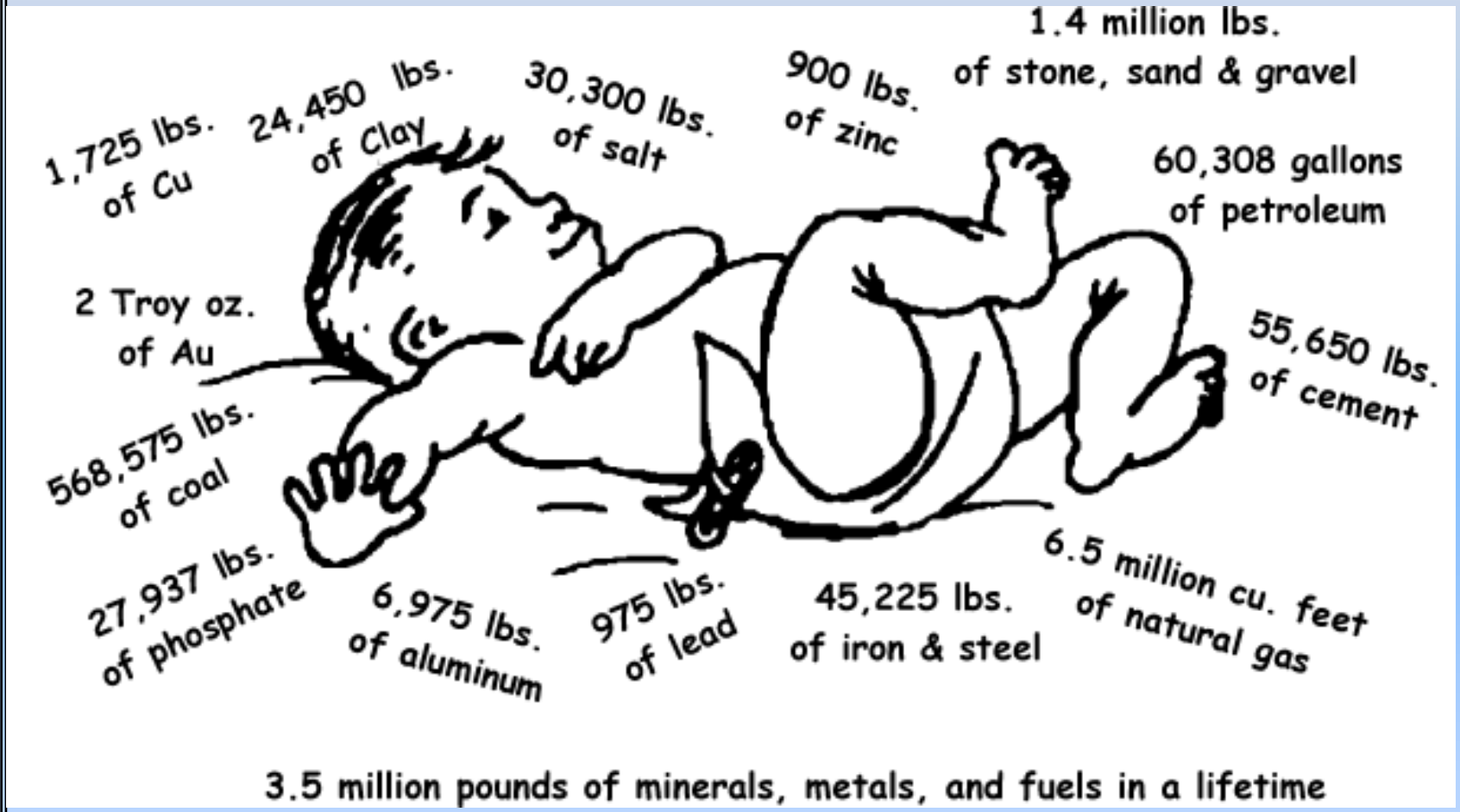
***Resources** are commonly divided into two broad categories:*

***Renewable Resources**: these resources can be replenished over relatively short time spans (e.g. plants, animals, wind, flowing water, and the Sun energy).*

***Nonrenewable Resources**: continue to be formed in Earth with fixed quantities (e.g. coal, oil and natural gas as fuels and iron, copper, gold, uranium as metals).*

I-Non-renewable resources
Mineral resources

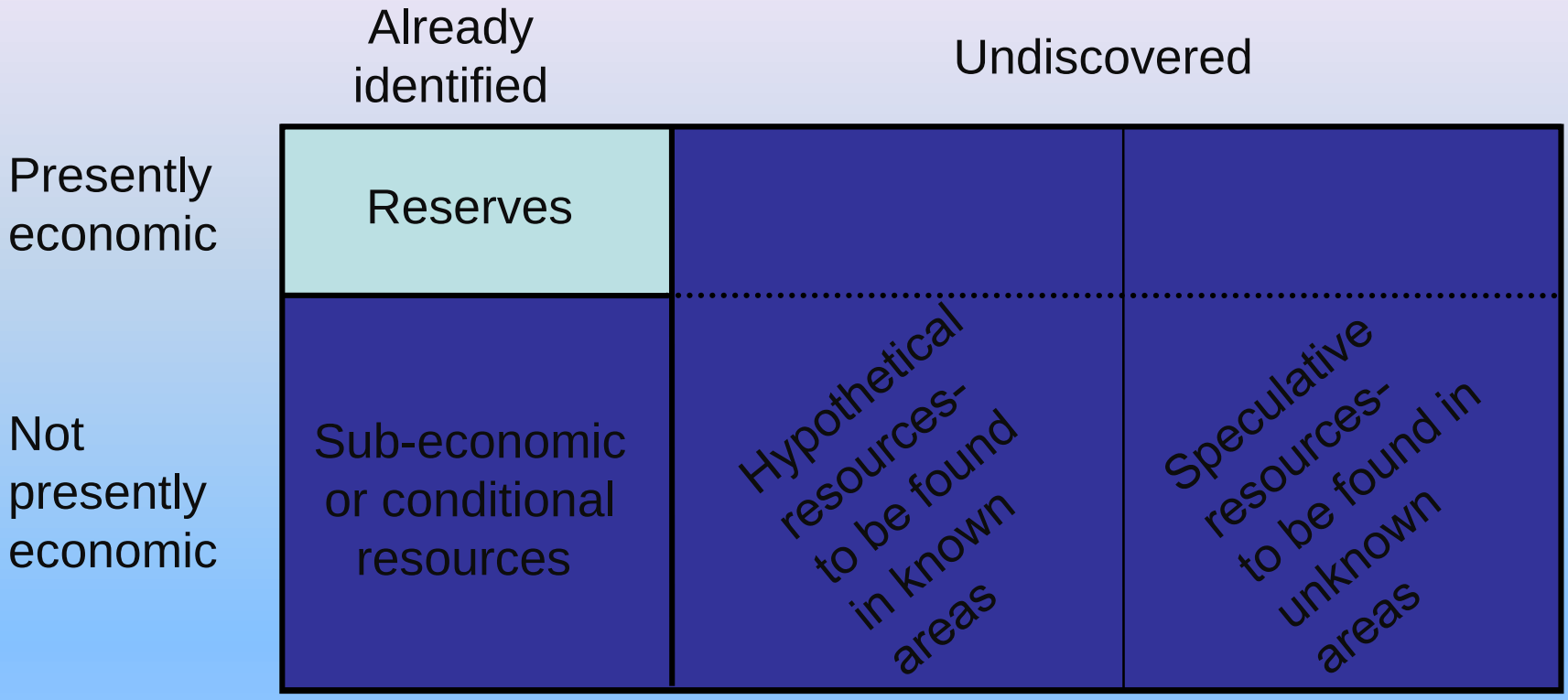
Every Egyptian Born Will Need….



Elements in your telephone

Element	How used
Aluminum	metal alloy in dial, transmitter, and receiver
Antimony, Arsenic, Beryllium, Bismuth	Alloy in dial
Boron, Germanium, Indium, Silicon	Dial mechanism
Cadmium	Color in yellow plastic housing
Calcium	In lubricant for moving parts
Carbon	Plastic housing, transmitter steel parts
Chlorine	wire insulation
Chromium	Color in green plastic, plating, stainless steel
Cobalt	magnetic material in receiver
Copper	wire, plating, brass piece parts
Fluorine	Plastic piece parts
Gold, Palladium, Platinum	Electrical contacts
Hydrogen	Plastic housing, wire insulation
Iron	Steel, magnetic materials
Krypton	Ringer in Touch-Tone set
Lead, Tin	Solder in connections
Lithium	In lubricant for moving parts
Magnesium	Die castings in transmitter, ringer
Manganese, Phosphorus, Sulfur	Steel in piece parts
Mercury	Color in read plastic housing
Molybdenum	magnet in receiver
Nickel	magnet in receiver, stainless steel parts
Nitrogen	Hardened heat-treated piece parts
Oxygen	Plastic housing, wire insulation
Silver, Tin	Plating
Sodium	In lubricant for moving parts
Tantalum	Integrated circuit in Trimline set
Titanium	Color in white plastic housing
Tungsten	Lights in Princess and key sets
Vanadium	Receiver
Zinc	Brass, die casting in transmitter, ringer

Reserves and Resources



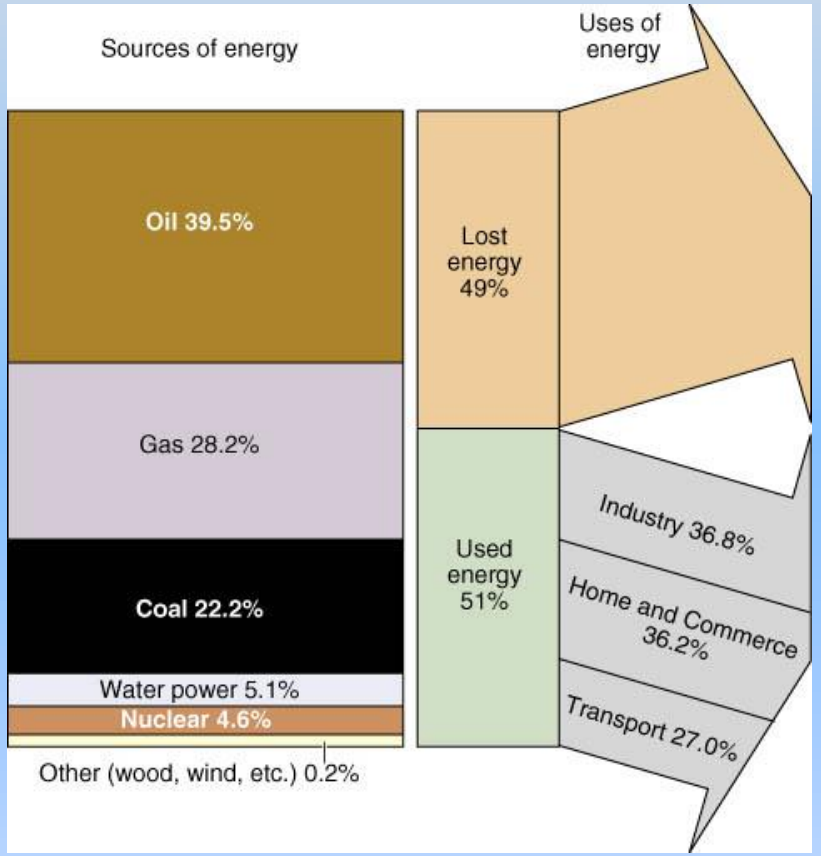
In order to assess how much of a mineral is available and will be available in the future, estimates based on *volumes and concentrations* of the minerals in known deposits, and predictions of deposits to be identified in the future, are made.

Estimates of undiscovered resources are based on what is known about the geology of certain deposits, where proper geological settings occur, the likelihood of finding more deposits, etc. These are inherently very rough estimates.

Energy Resources

- **The uses of energy can be grouped into three categories:**
  - **Transportation.**
  - **Domestic use.**
  - **Industry (meaning all manufacturing and raw material processing plus the growing of foodstuffs).**

- Most energy used by humans is drawn annually from major fuels:
  - Coal.
  - Oil.
  - Natural gas.
  - Nuclear power.
  - Wood and animal dung (Biomass).

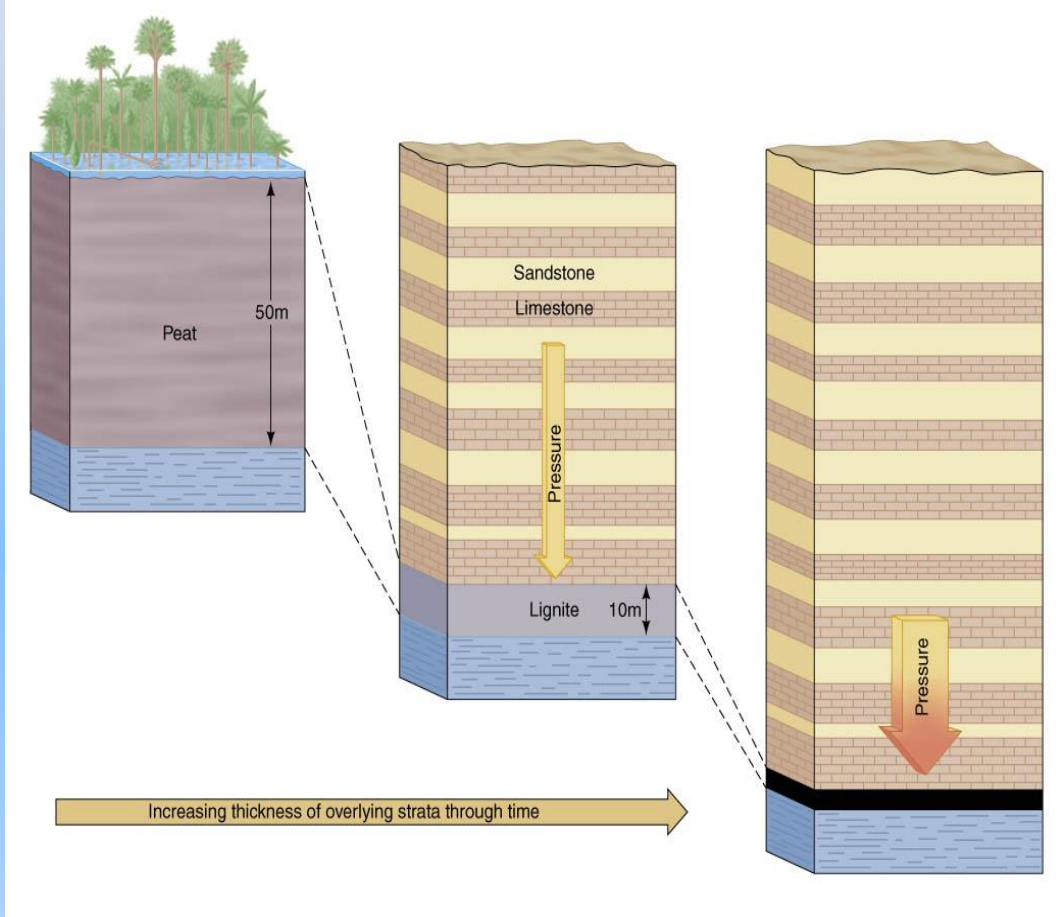


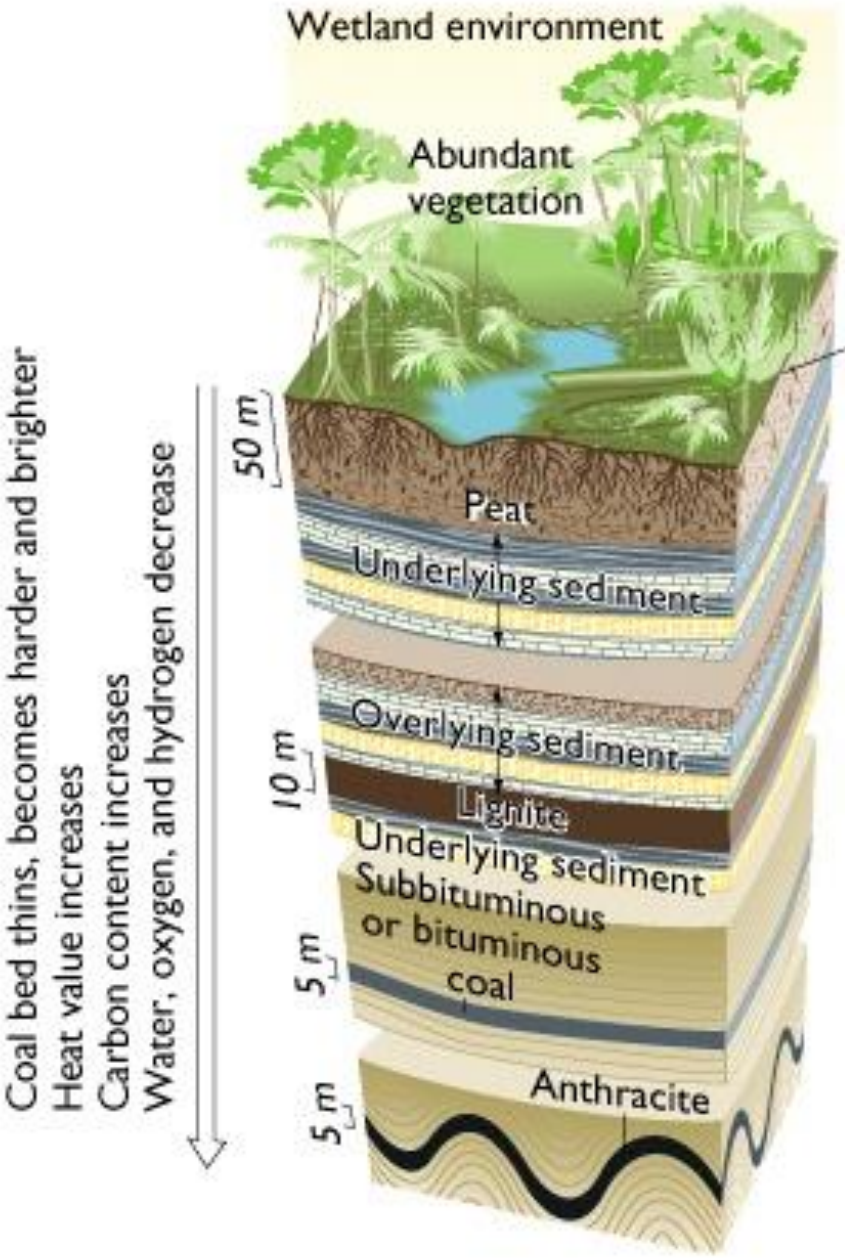
Fossil Fuels

- The term **fossil fuels** refers to the remains of plants and animals trapped in sediment that can be used for fuel.
- The kind of sediment, the kind of organic matter, and the processes that take place as a result of burial and diagenesis, determine the kind of fossil fuel that forms.

Coal

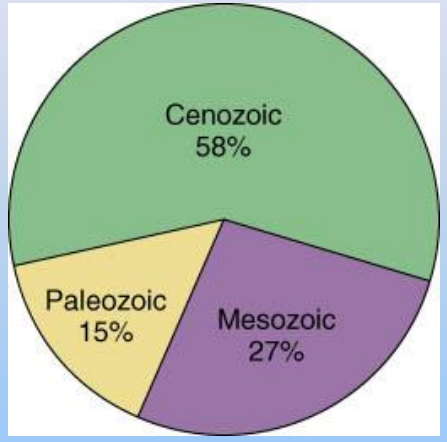
- Coal is the most abundant fossil fuel.
- It is the raw material for nylon, many other plastics, and a multitude of other organic chemicals.
- Through coalification, peat is converted to lignite, subbituminous coal, and bituminous coal.
- Anthracite is a metamorphic rock.

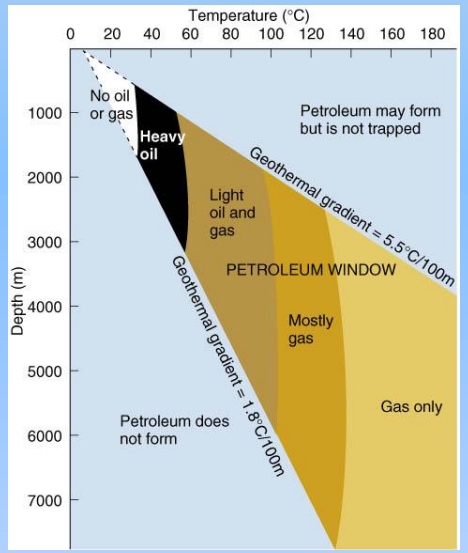



Wetland environment
Abundant vegetation
Surface accumulation of leaf litter, twigs, branches, and other fragments of vegetation
50 m
Peat
Underlying sediment
Lower buried swamp deposits partly decayed, compressed to peat
10 m
Overlying sediment
Lignite
Underlying sediment
Shallow burial: transformation of peat to lignite
5 m
Subbituminous or bituminous coal
Further burial under hundreds to thousands of meters of sediment: transformation of lignite to soft coal
5 m
Anthracite
Continued burial and structural deformation: heat metamorphoses soft coal to hard coal
Coal bed thins, becomes harder and brighter
Heat value increases
Carbon content increases
Water, oxygen, and hydrogen decrease

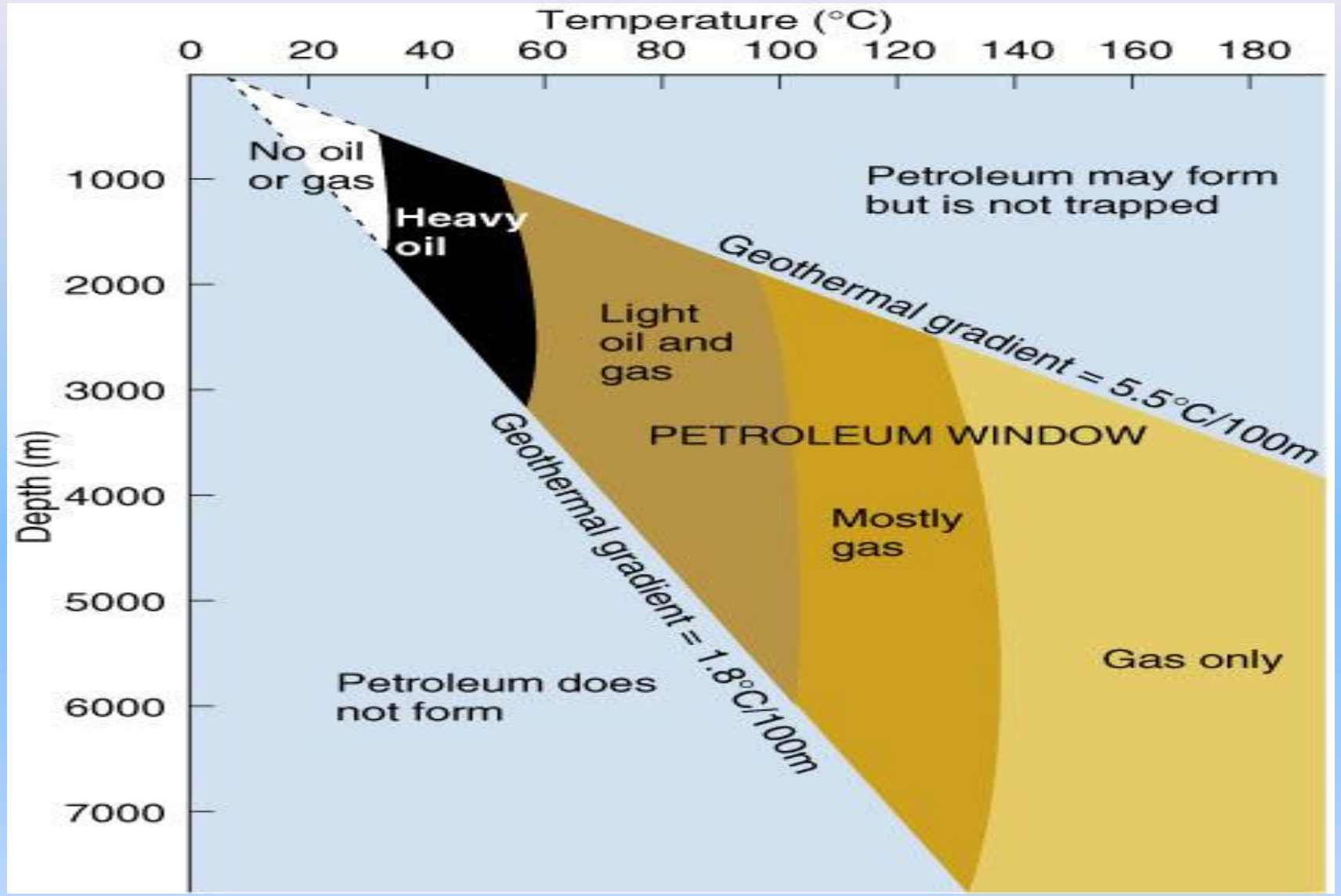
Petroleum: Oil and Natural Gas

- The term petroleum describes all hydrocarbons (gaseous, liquid, or solid) found in rocks
- Natural gas is composed mostly of methane (99 percent) with small amounts of ethane, propane.
- Petroleum is a product of the decomposition of organic matter trapped in sediment.
- Nearly 60 percent of all the oil and gas discovered so far has been found in strata of Cenozoic age.
- Petroleum migration is analogous to groundwater migration. When oil and gas are squeezed out of the shale in which they originated and enter a body a sandstone or limestone, they can migrate easily.
- Because it is lighter than water, the oil tends to glide upward, until it encounters a trap.





Petroleum: Oil and Natural Gas



Tars

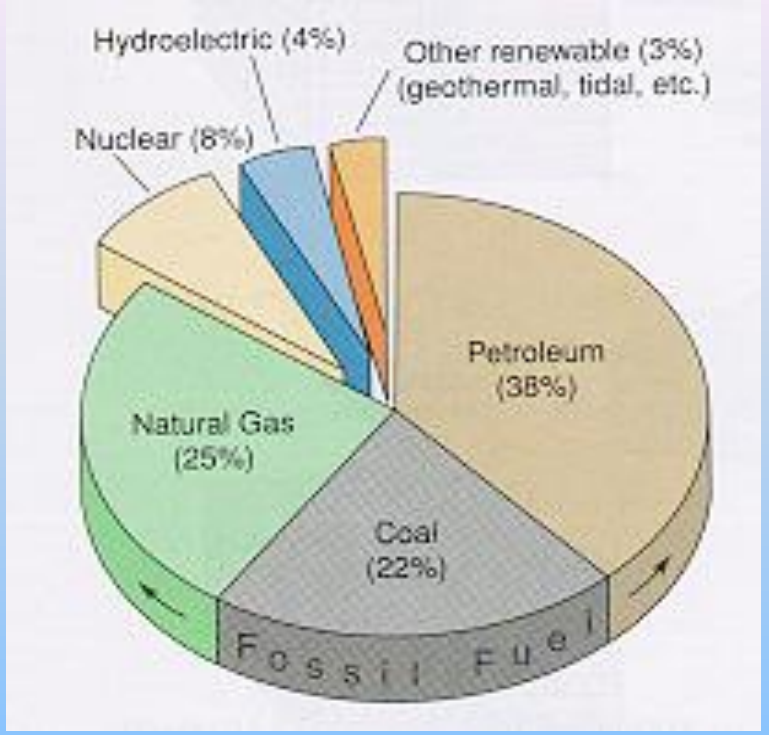
- Tar is made of oil that is exceedingly viscous;
  - The largest known occurrence of tar sand is in Alberta, Canada, where the Athabasca Tar Sand covers an area of 5000 km2 and reaches a thickness of 60 m.
  - Similar deposits, almost as large, are known in Venezuela and in Russia.

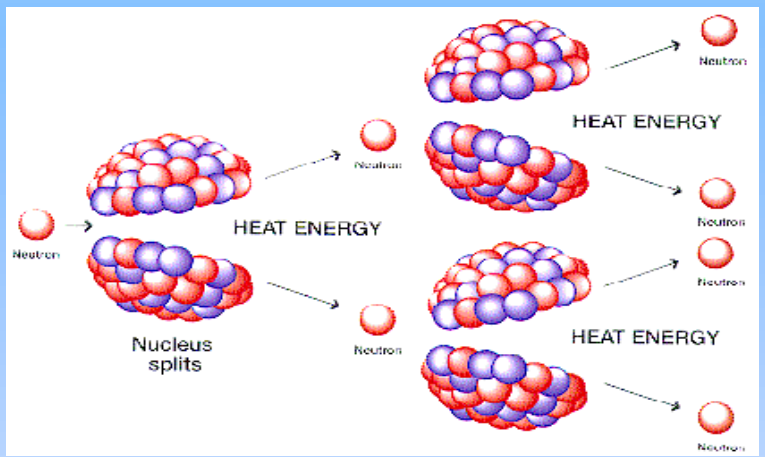
Oil Shale

- The world's largest deposit of rich oil shale is in Colorado, Wyoming, and Utah.
- Only oil shale that produces 40 liters of oil per ton are worth mining.
- The richest shales in the U.S. are in Colorado: they produce as much as 240 liters of oil per ton.
- Production expenses today make exploitation of oil shales in all countries unattractive by comparison to oil and gas.

Alternative sources: non-fossil fuels

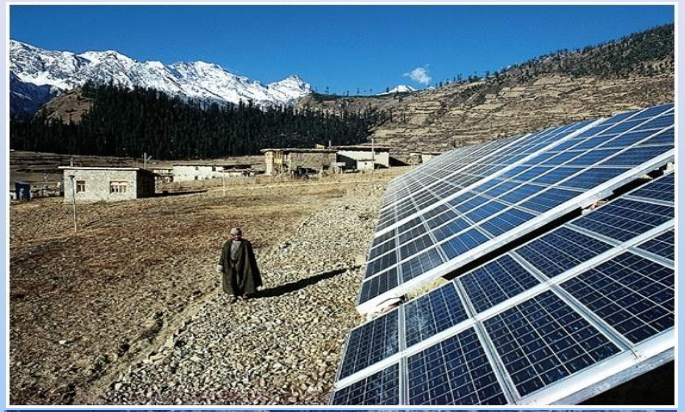
- Biomass energy:
  - Wood and animal dung.
- Hydroelectric power.
- Nuclear energy.
  - Heat energy is produced during controlled transformation (fission) of suitable radioactive isotopes.
  - Three of the radioactive atoms that keep the Earth hot by spontaneous decay—238U, 235U, and 232Th—can be mined and used to obtain nuclear energy.





Other Sources of Energy

- Geothermal power.
  - Geothermal power is produced by tapping the Earth's internal heat flux (Italy, Iceland and the United States).
- Energy from winds, waves, tides, and sunlight:
  - Winds and waves are both secondary expressions of solar energy.
  - Winds have been used as an energy source for thousands of years through sails on ships and windmills.
  - Steady surface winds have only about 10 percent of the energy the human race now uses.

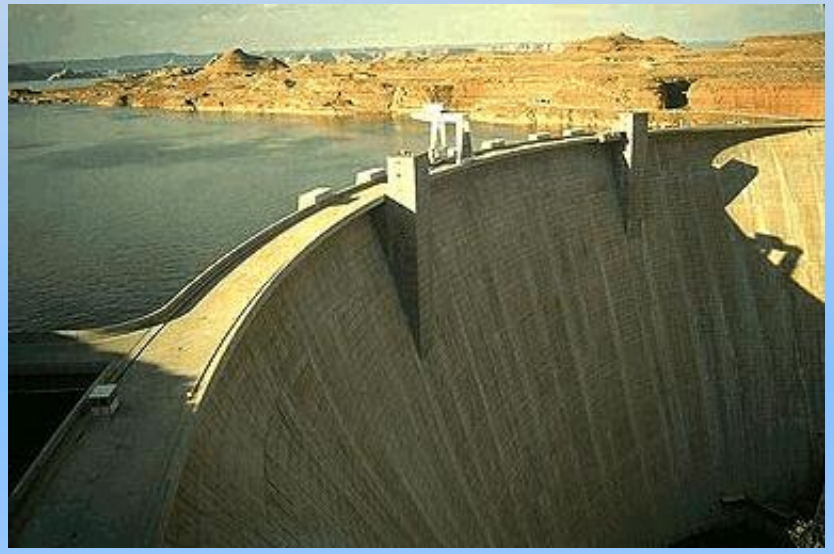


The Geysers geothermal power plant, CA

Street "clearing" using geothermal heat, Japan

Other Sources of Energy

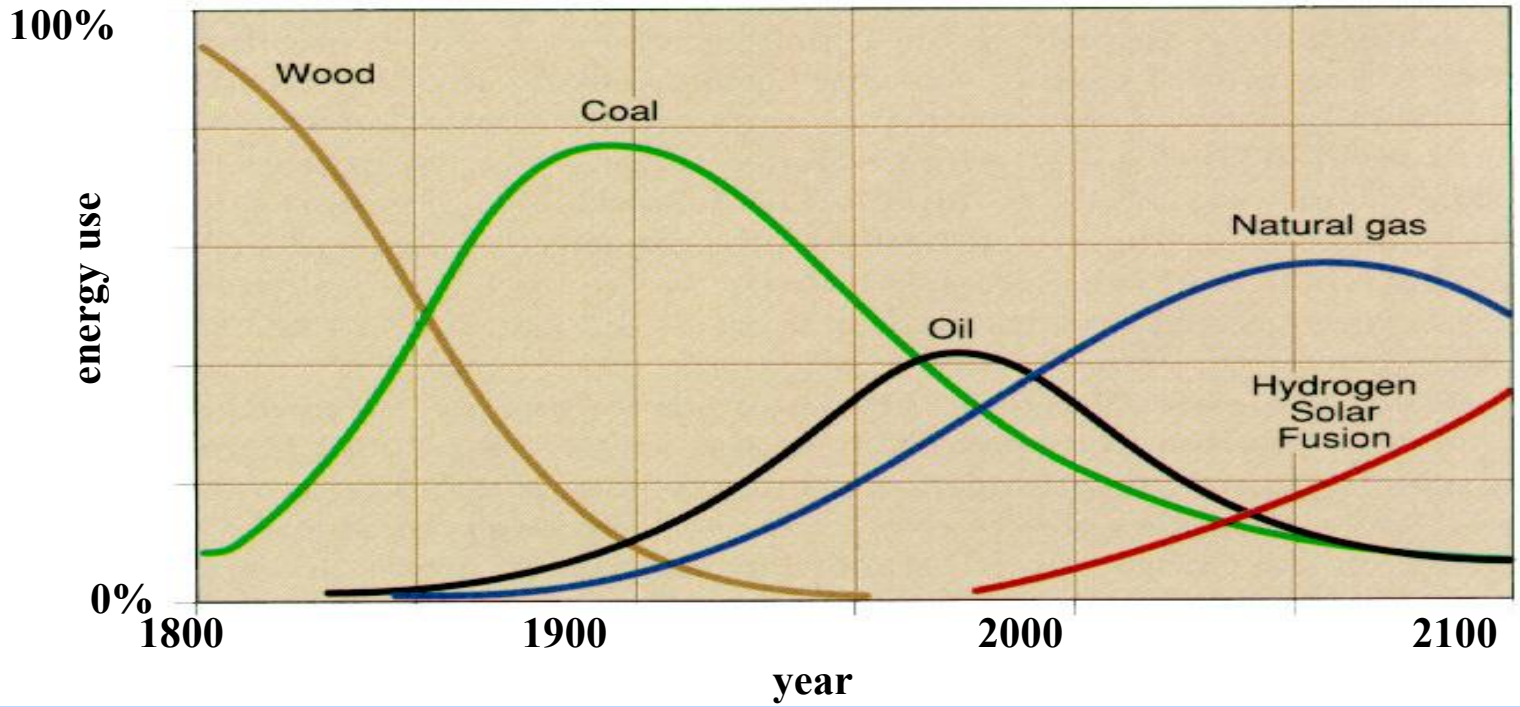
- Tides arise from the gravitational forces exerted on the Earth by the Moon and the Sun.
  - If a dam is put across the mouth of a bay so that water can be trapped at high tide, the outward flowing water at low tide can drive a turbine.



Glen Canyon hydro-electric dam, CO

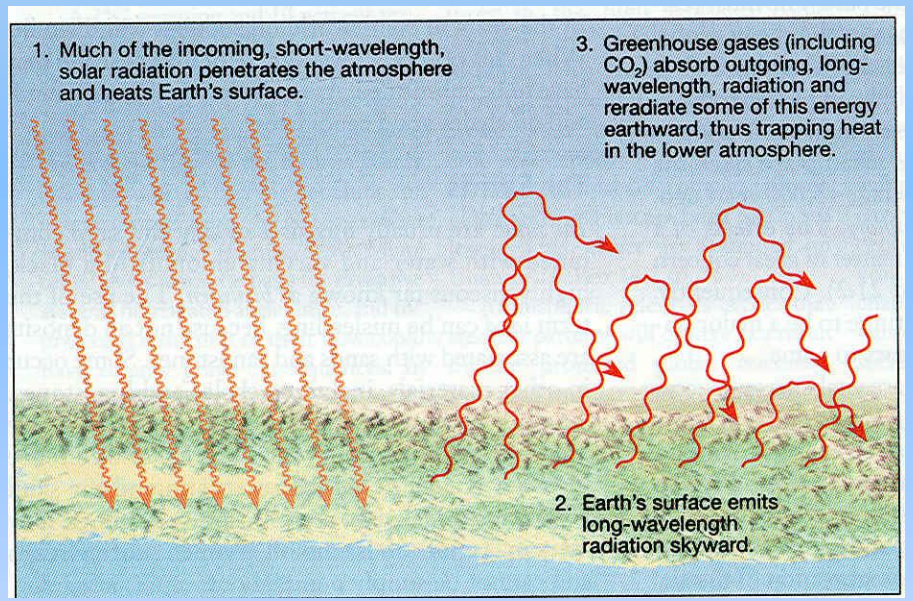
Consumption Rates

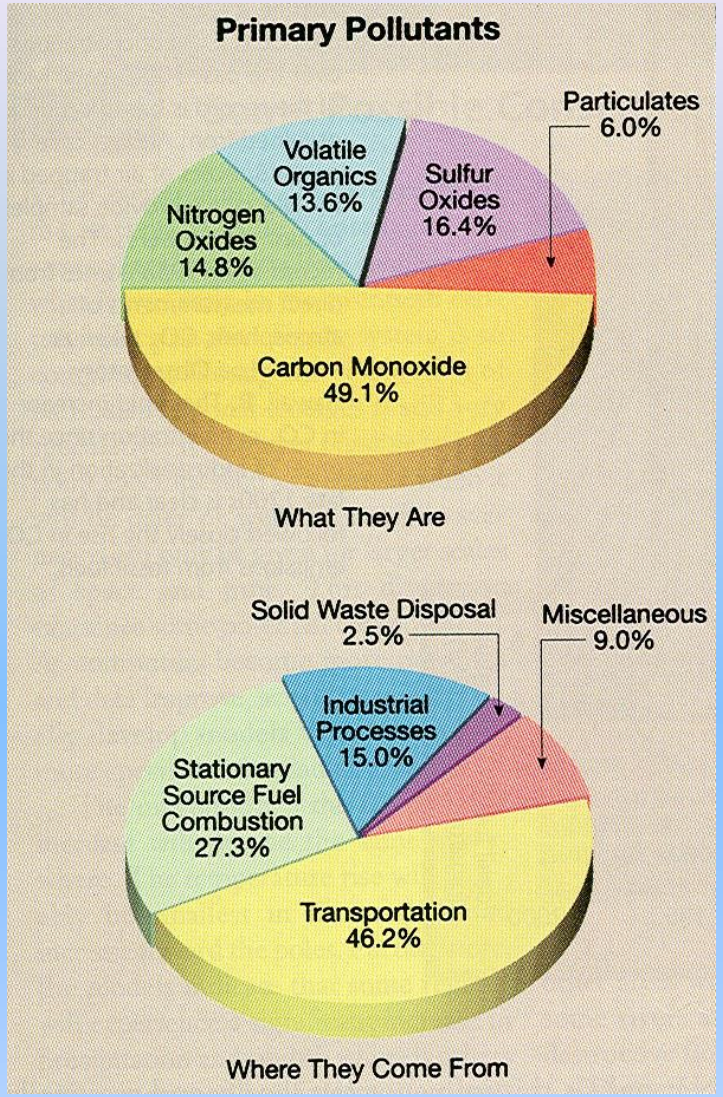
- For the world as a whole, the consumption rate is about 9 tons per person per year.
- About 54 billion tons of material is dug up and used each year.



Fossil energy: environmental impacts

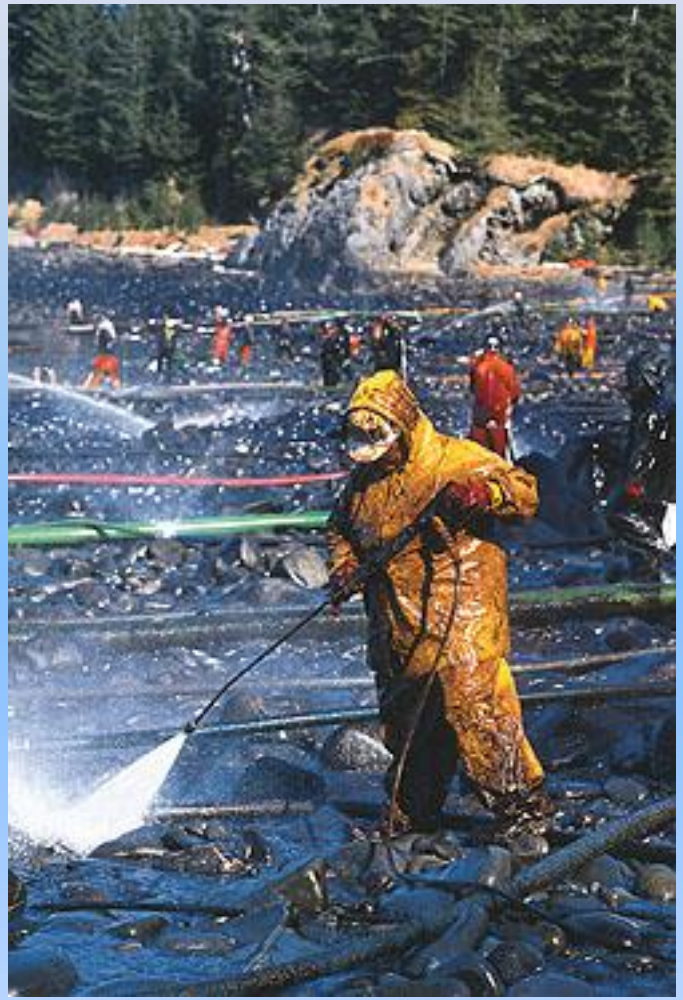
- Urban Air Pollution
- Acid Rains
- Carbon Dioxide and Global Warming





Fossil energy: environmental impacts

Another price of oil!



Nuclear energy: environmental impacts

The most spectacular potential environmental effect of nuclear power generation is *reactor melt-down* (cooling system fails; temperature in reactor core rises uncontrollably). Examples include Three-Mile Island, PA, and Chernobyl, Ukraine. Proper safety measures make the likelihood of such events small.

1 Uranium fuel pellet will produce as much electricity as:

1 ton of coal

2-1/2 tons of wood

3 barrels of oil (126 gallons)

17,000 cubic feet of natural gas

Disposal of nuclear power generation by-products (reactor water, depleted fuel, decommissioned reactors, etc.) poses an immediate environmental problem for which a long-term solution has not yet been developed.

These by-products are and *will remain radioactive for hundreds of years* to come. Current research into deep underground disposal of such waste is promising, but there are problems.

- **Geological Hazards**
  - **Types of Natural Hazards**
  - **Natural Risk Zones & its consequences**

NATURAL HAZARDS

- Natural processes are physical, chemical, and biological changes that modify the landscape
- Internal processes are driven by changes deep in earth such as

1. earthquake
2. or volcanic eruptions

- Surface processes (close to Earth's surface) include

1. landslides,
2. flooding,
3. coastal erosions,
4. violent storms
5. and wildfires.

NATURAL HAZARDS

The most devastating natural hazards are:

- **Earthquake**
- **Volcanic Eruptions**
- **Landslides**
- **Hurricane**
- **Tsunami**
- **Wildfire**
- **Tornado**
- **Flood**
- **Heat Wave**
- **Drought**

NATURAL HAZARDS

Flooding following Hurricane Katrina, New Orleans, 2005

Urban Earthquake, Los Angles, 1994

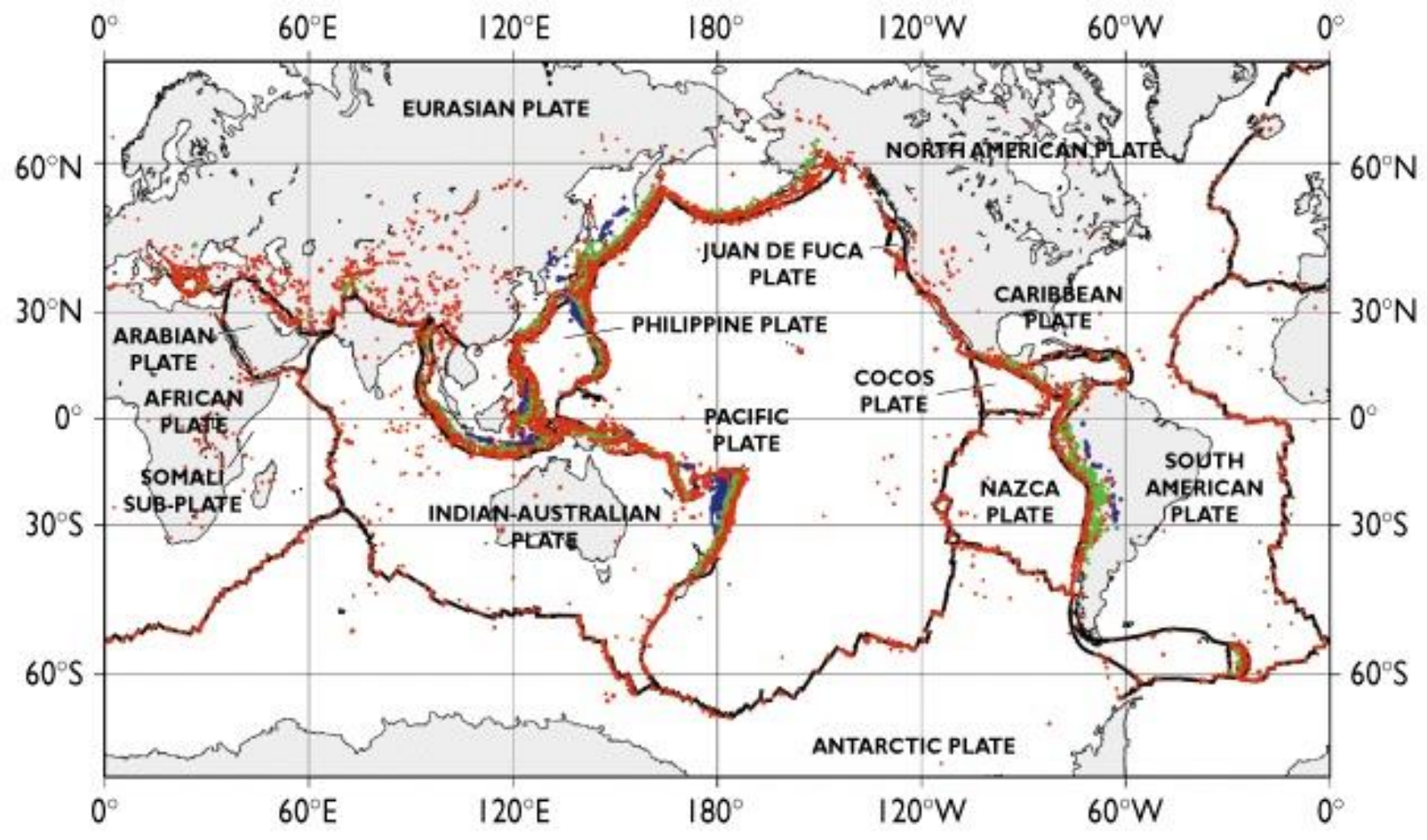
Earthquakes

Why study earthquakes?

- Understand the hazard to minimize the risk
- Study of earthquakes, issuing tsunami warnings
- Detection of atomic explosions for verification of the Comprehensive Test Ban Treaty

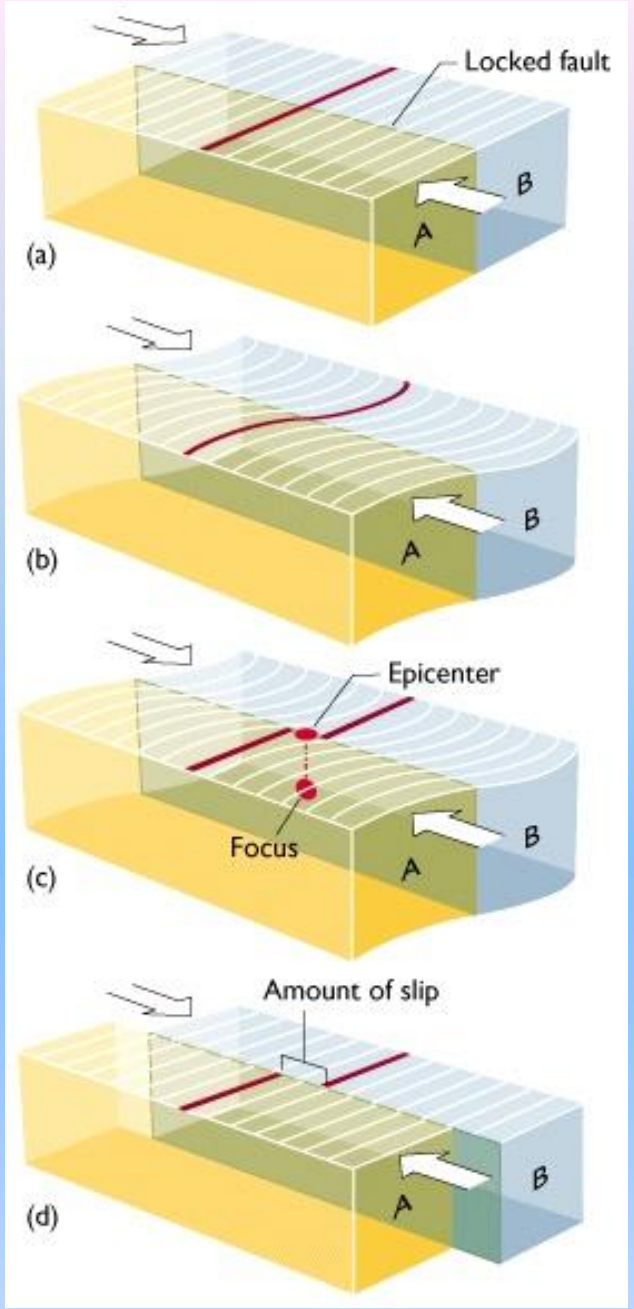
Damage in Golcuk, Turkey after a magnitude 7.4 earthquake, August 17, 1999

World Seismicity



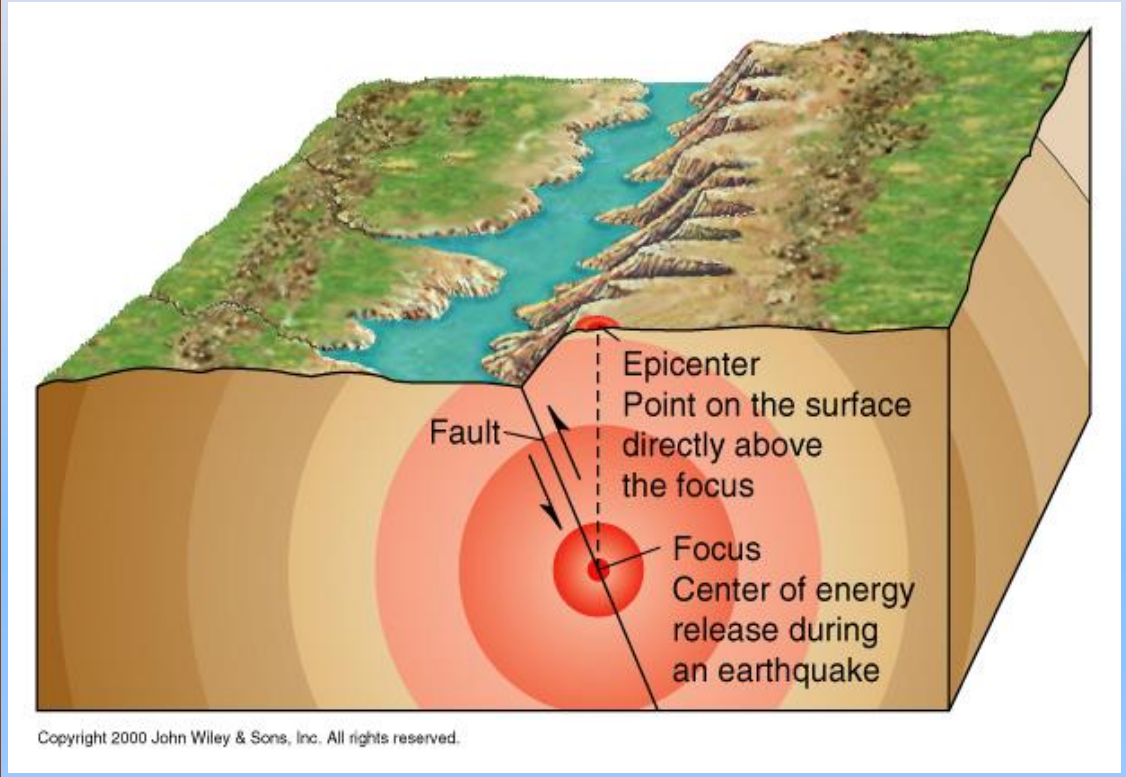
Earthquakes

- Earthquakes release accumulated strain by the sudden displacement of faults.
- Elastic Rebound Theory: "energy can be stored in elastically deformed rock, earthquakes release that stored energy and the rock returns to its undeformed state".
- Strain accumulates (a, b) until released by an earthquake (c) and the resulting slip (d).



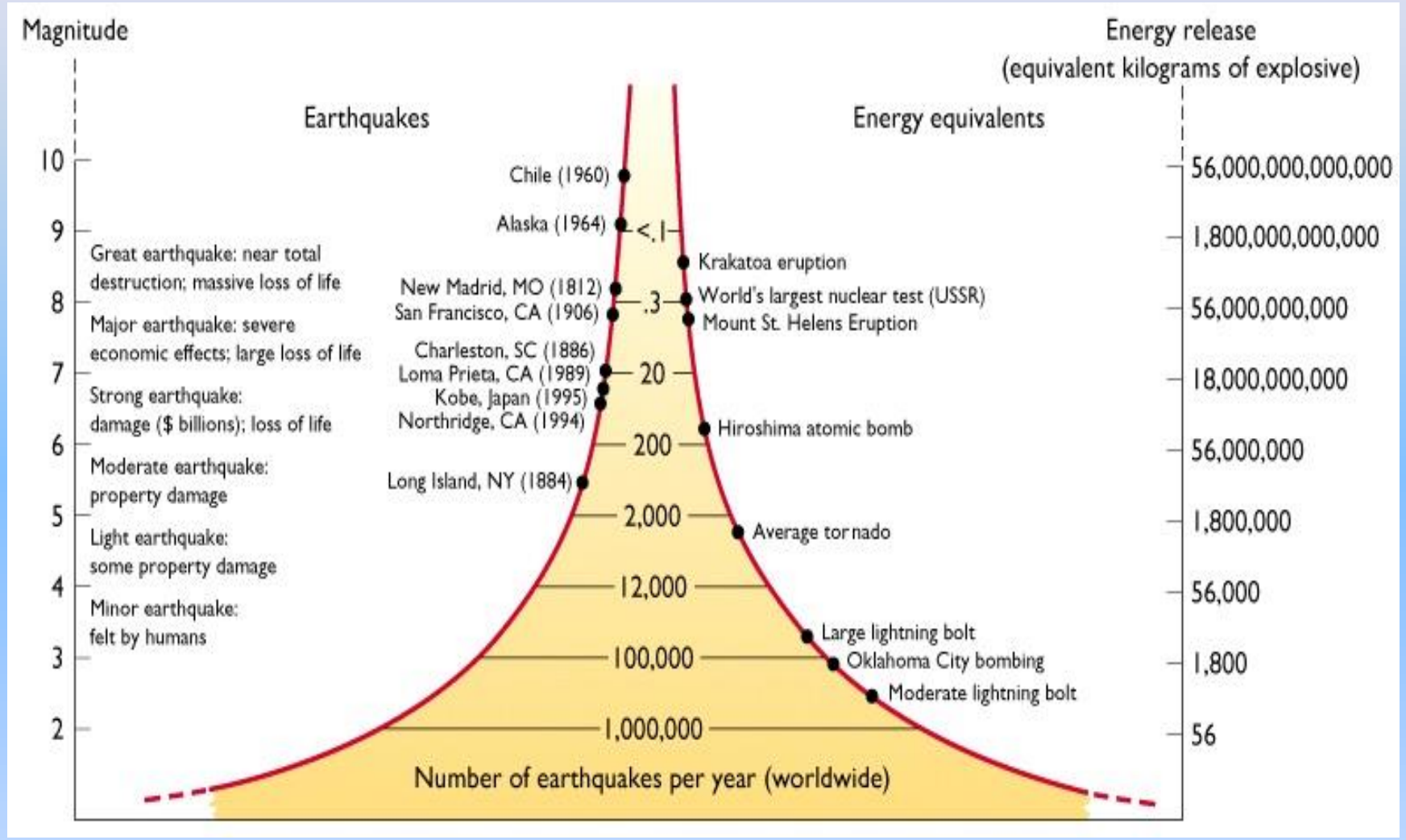
Location of an Earthquake

- Earthquake focus – location where seismic energy is first released.
- Epicenter – the point on the surface directly above the focus.



- **Slip of nearly 3 m as a result of the 1906 San Francisco earthquake.**

Earthquake magnitude and energy

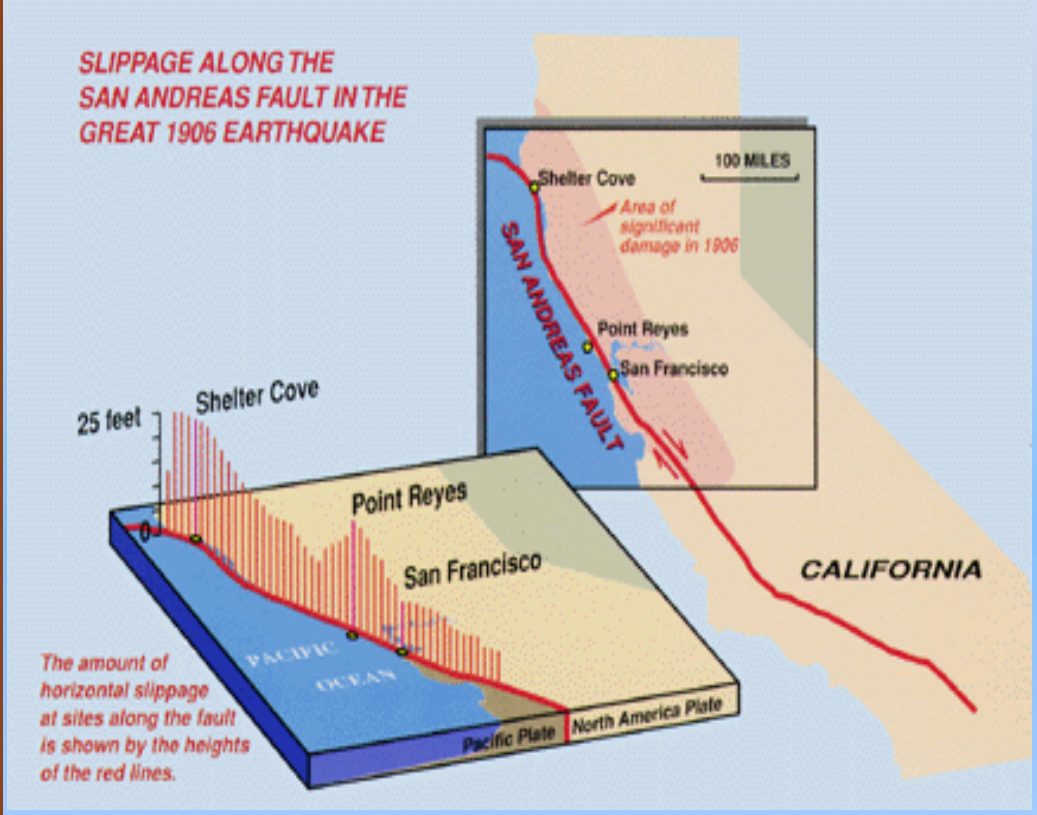


Earthquake damage

- Ground motion due to seismic waves
- Fault rupture of the ground surface
- Fire
- Mass-wasting
- Liquefaction
- Tsunami

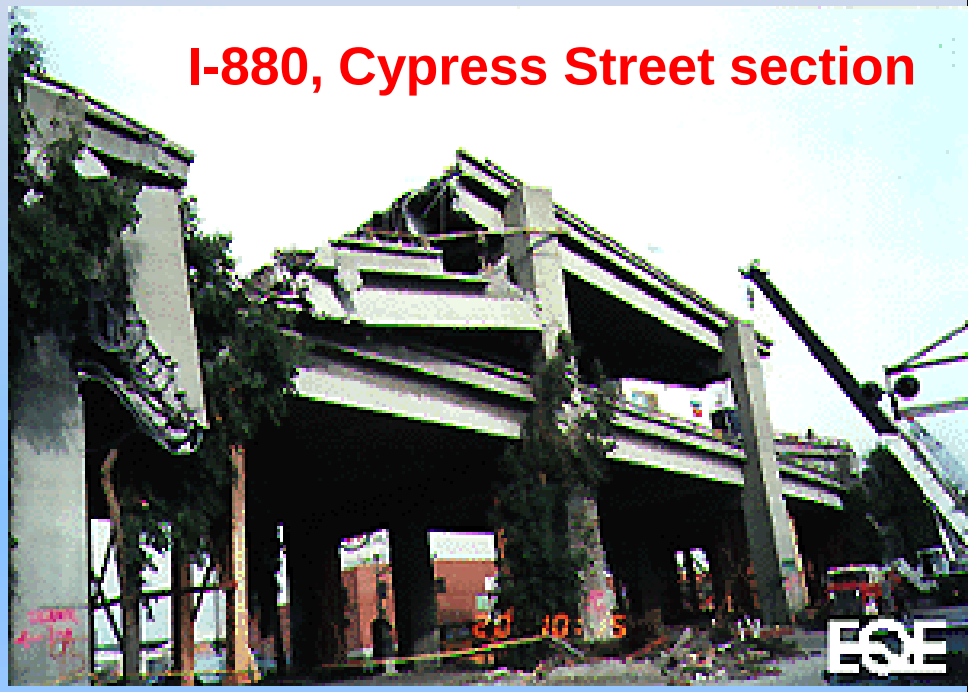
The 1906 Earthquake

- April 18, 1906, a powerful earthquake (magnitude 7.8) struck Northern California.
- The ground broke over nearly half the length of California (about 300 miles).
- U.S. Geological Survey scientists shows that slippage locally exceeded 25 feet near both Point Reyes and Shelter Cove, 150 miles apart on the coast north of San Francisco.



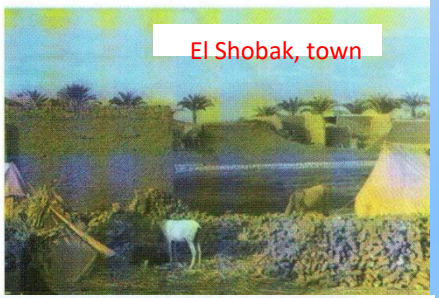
Loma Prieta Earthquake (1989)

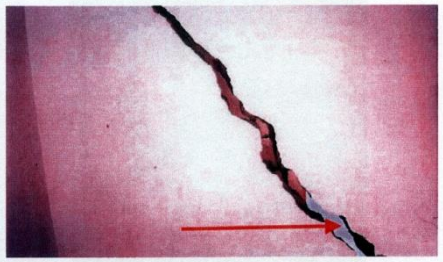
- Richter magnitude 7.1 earthquake
- Epicenter about 10 miles NE of Santa Cruz along a segment of the San Andreas Fault, near Loma Prieta in the Santa Cruz Mountains.
- Focal depth ~ 11 miles.Typical California earthquake focal depths are 4 to 6 miles.



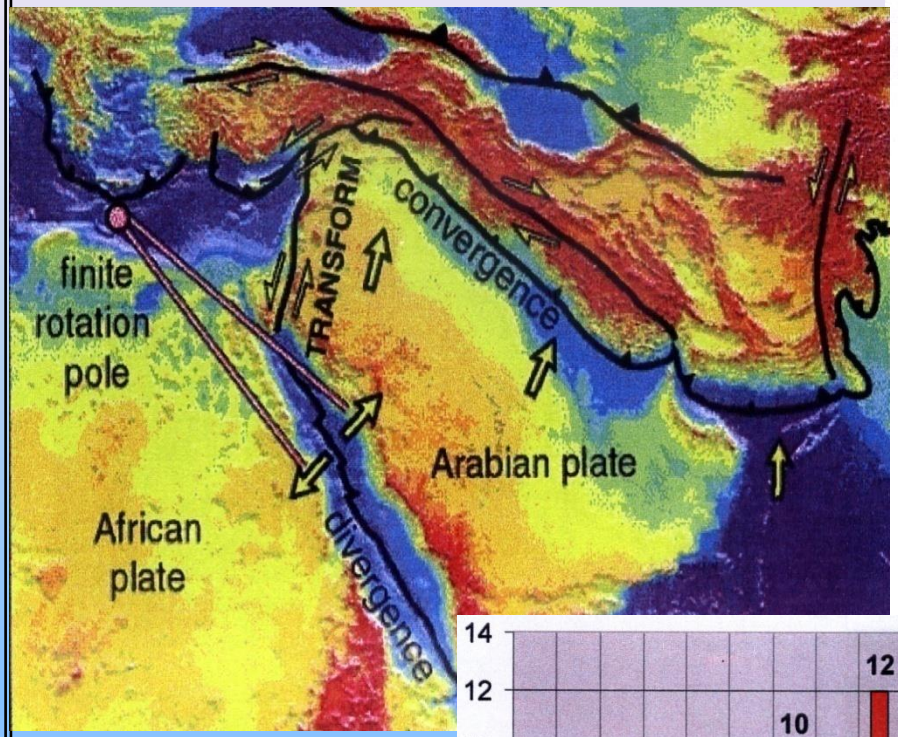
Egypt,"1992 Earthquake"

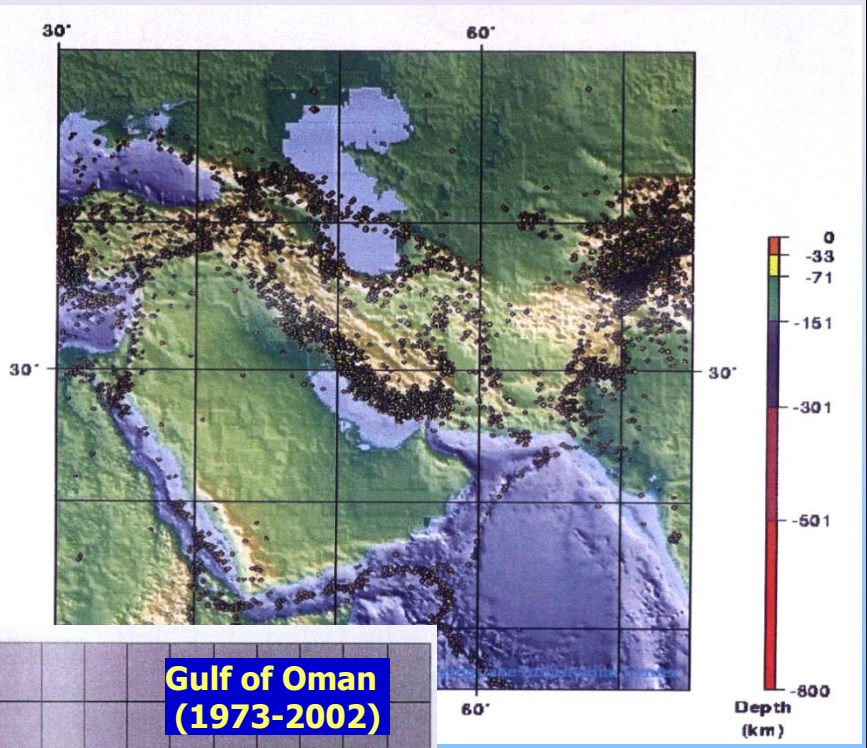
- On Monday, 12th October 1992, Egypt was hit by one of the largest earthquakes in its recent history.
- This event shook Cairo and the northern part of the Nile valley and was felt in much of Egypt from Alexandria to Aswan causing widespread damage.
- The intensity in the epicentre area (Dahshur area, 35 km southwest Cairo) was of VIII degree on the Modified Mercalli intensity scale (5.3-6 by Richter scale).
- The focal mechanism solution indicates a normal faulting with a strike-slip component.
- This earthquake had widespread consequences mainly because so many buildings were destroyed due to their poor quality.

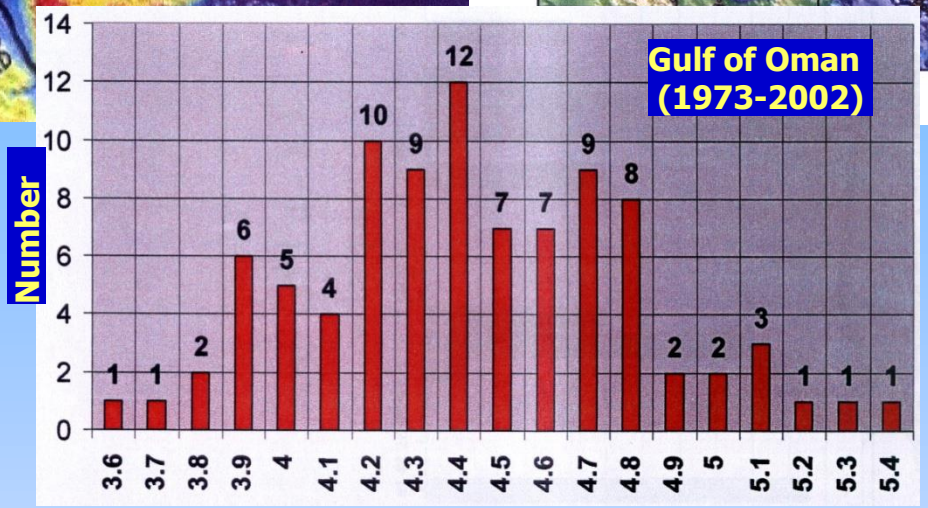

El Shobak, town



Arabian Plate's Earthquakes







Mass Wasting

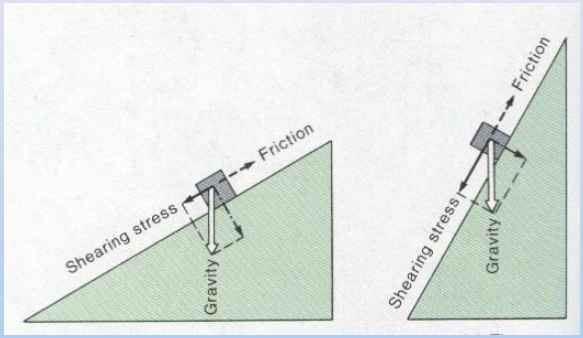
- Definition
- Types of mass wasting
- Consequence of mass movements
- Impact of Human activities
- Possible preventive measures

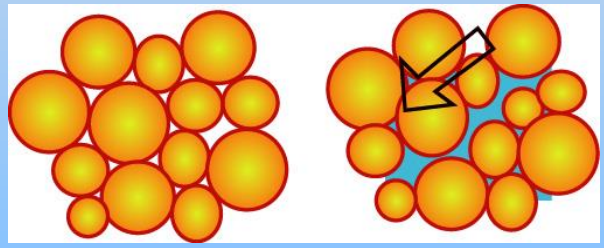
“Mass wasting”

- Mass wasting is comprehensive term for any type of downslope movement of earth materials (e.g. rock, regolith, soil..)
- force of gravity dominates
- distinct from erosional processes (Erosion without transporting agent i.e., (wind/water/ice).
- follows weathering
- mass-wasting + running water = stream valleys
- The mass movement can be slow, subtle, or sudden

Controls and triggers

- controlling force: **gravity**
- other important factors:



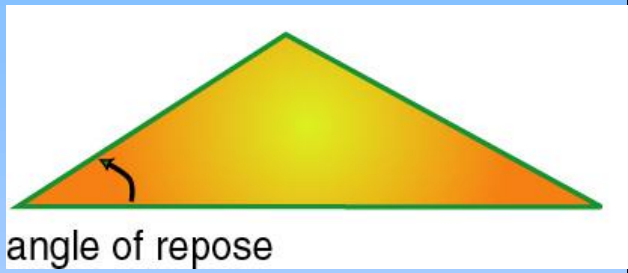


☞ water saturation

Water fills pore spaces between sediments, reduces internal resistance, adds weight

☞ steep slopes

Too steep = unstable
angle of repose = steepest stable angle of a slope



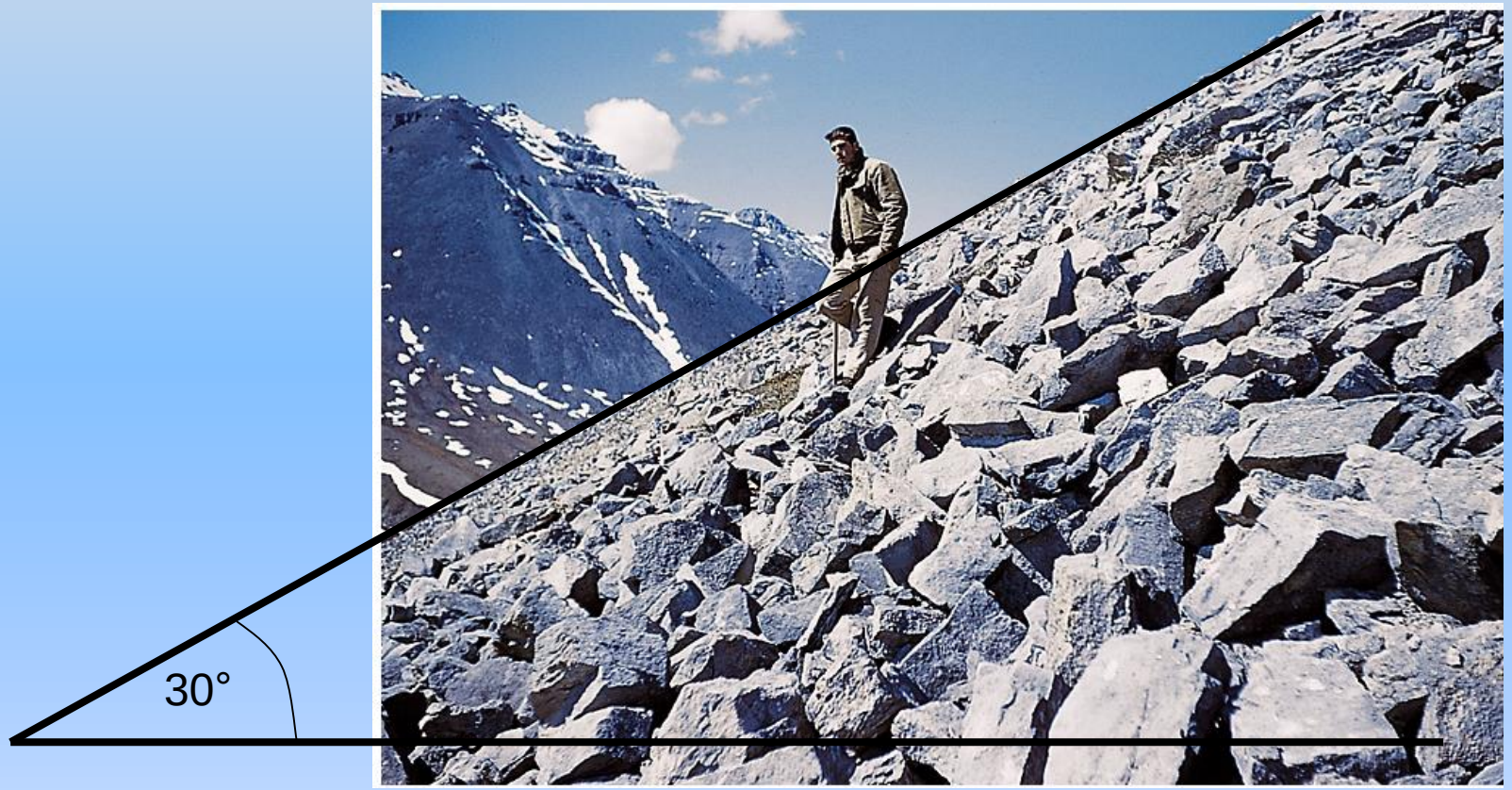
☞ vegetation removal

Plants add slope stability by protection against erosion

☞ earthquakes Strong ground vibrations

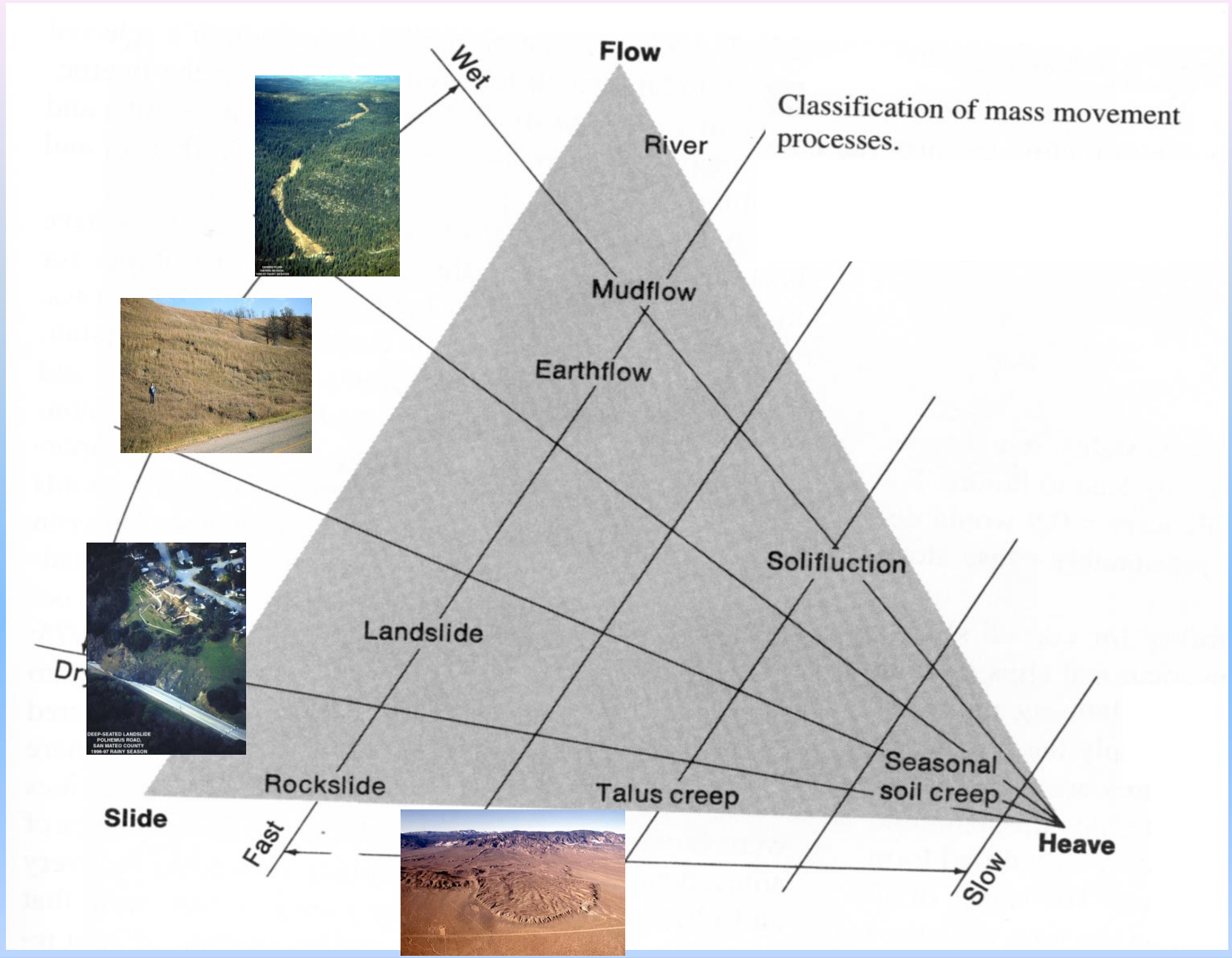
Angle of Repose

- Angle of repose – the steepest angle at which the debris remains stable
  - Typically between 30 to 37°



Triggers for rapid Mass Wasting

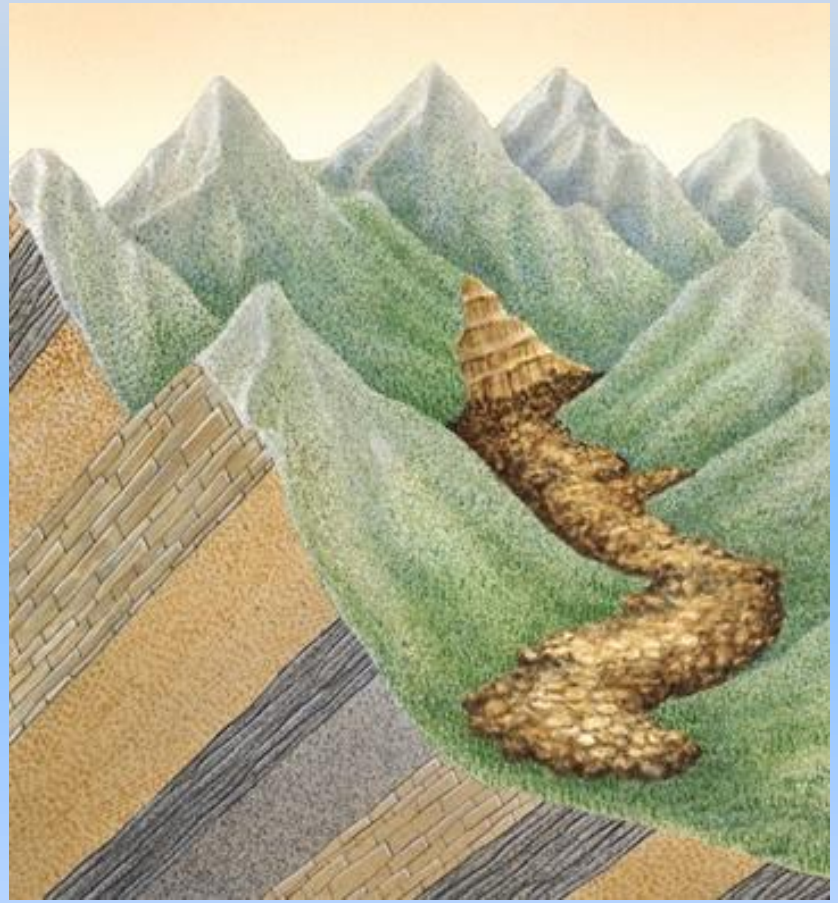
- **Rain**
- **Oversteepening**
  - **cutting at foot of slope**
  - **piling on head of slope**
- **Deforesting / Devegetating**
- **Earthquakes**


Flow
Wet
River
Classification of mass movement processes.
Mudflow
Earthflow
Solifluction
Landslide
Dry
Seasonal soil creep
Rockslide
Talus creep
Slide
Fast
Slow
Heave

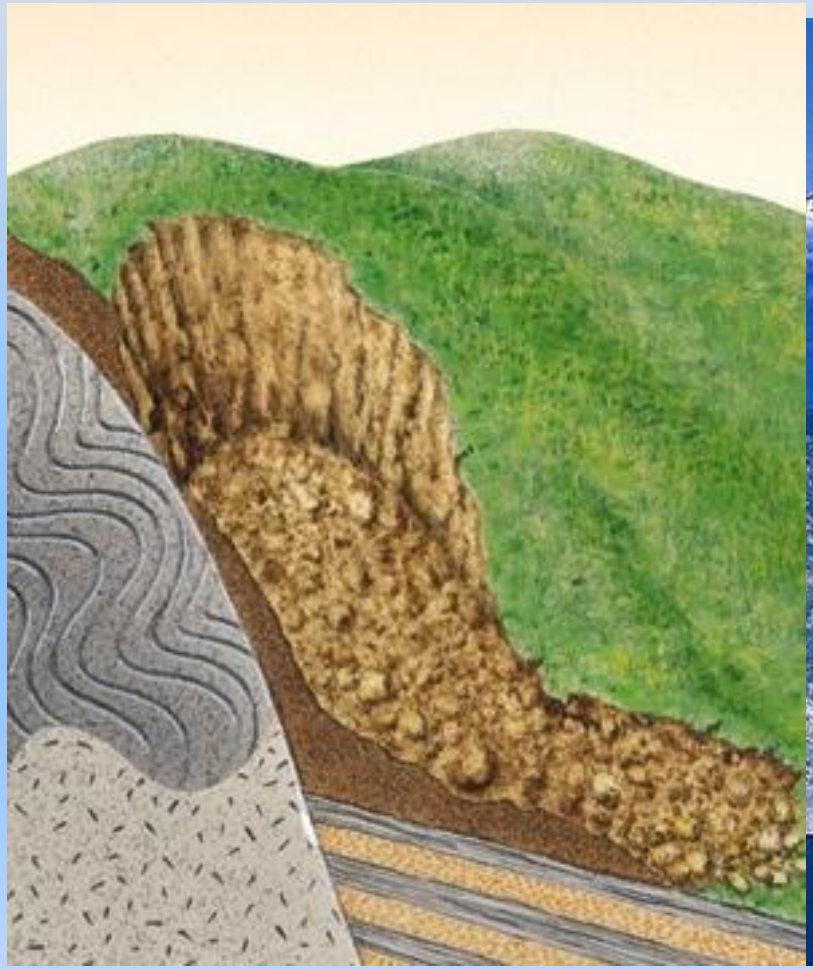
Mass Wasting include:

- Rock avalanche
- Debris avalanche
- Rockfall
- Rockslide
- Debris slide
- Debris flow
- Mudflow
- Earthflow
- Slump
- Creep

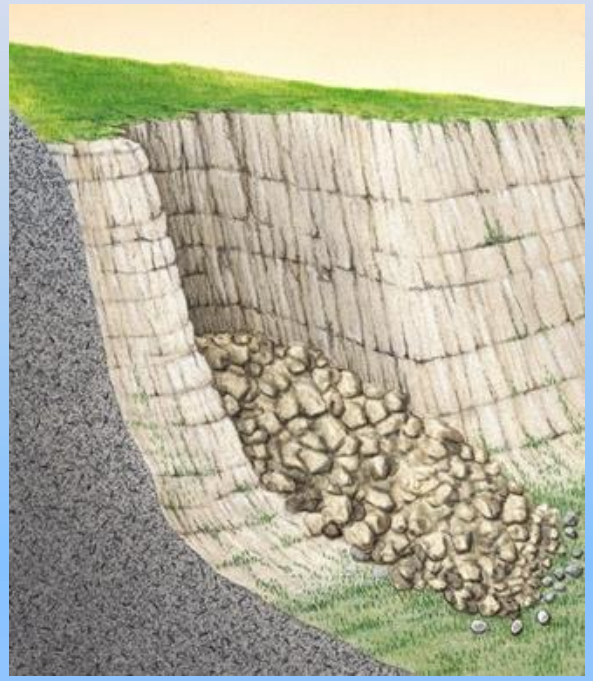
Rock avalanche



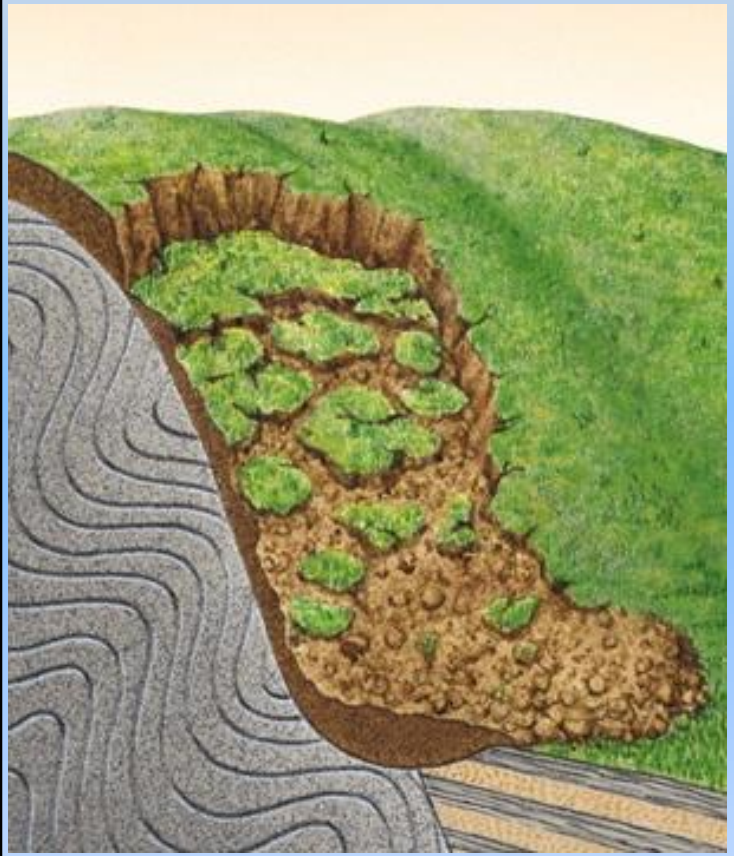
Debris avalanche



Rock falls



Debris slide



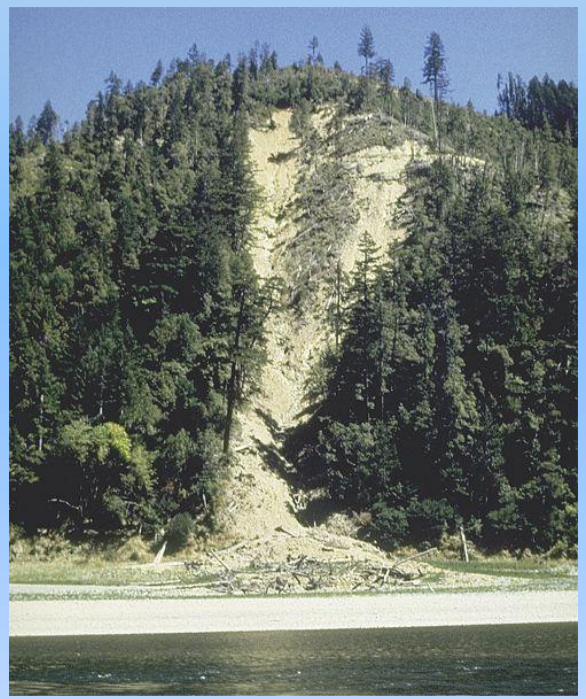
Complex landslide at La Conchita, California (1995)

Complex landslide

Complex landslide

Debris flow

- Flow of soil/regolith containing large amount of water
- Some also called mudflows , “mudslide”
- Common to semi-arid regions, volcanoes
- moderate to very fast movement, Very hazardous



Earthflow

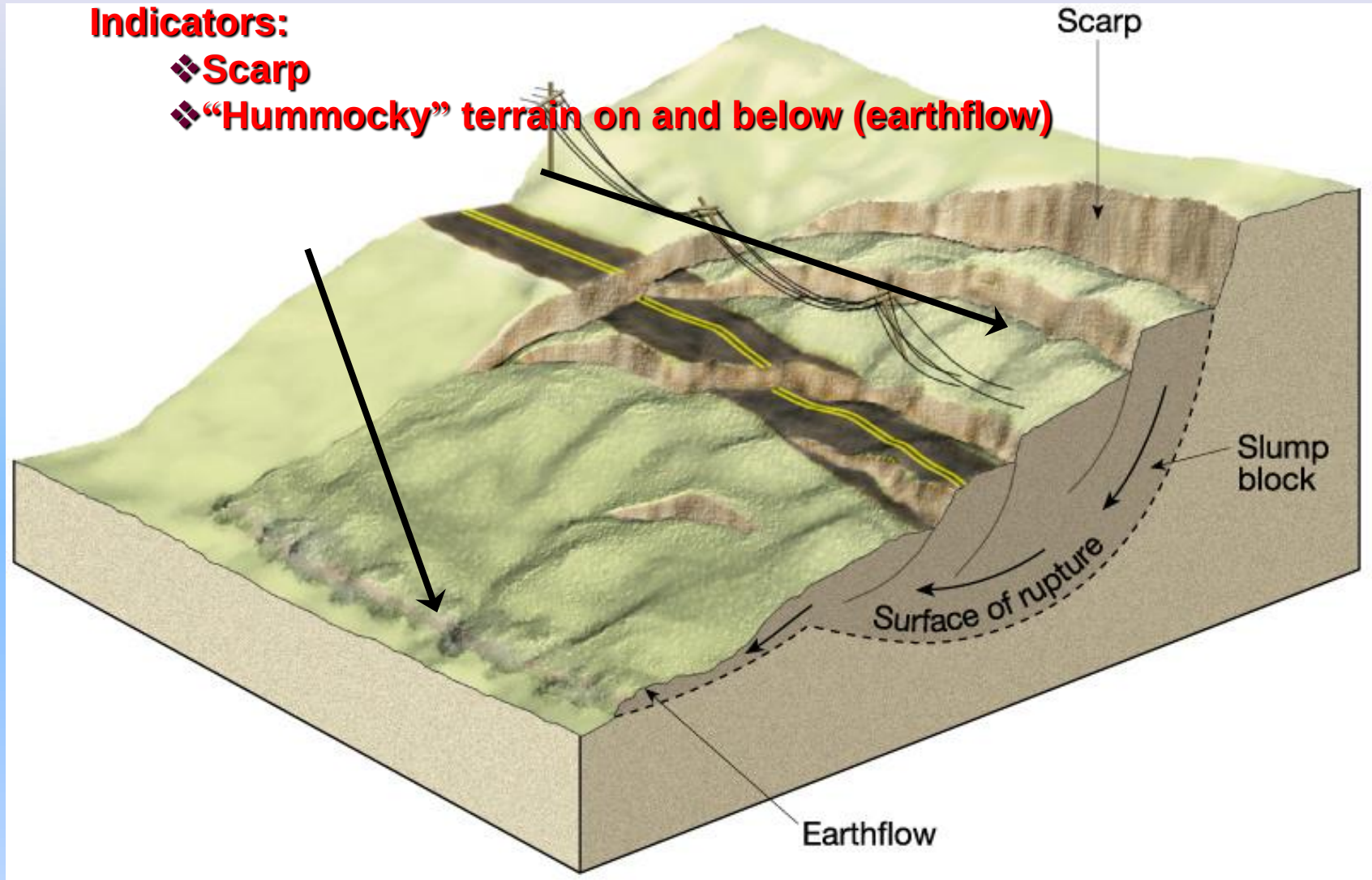
- humid areas
- hillsides
- rich in clay/silt
- slow rates

Earthflow, California

Slump (a type of slide)

Indicators:

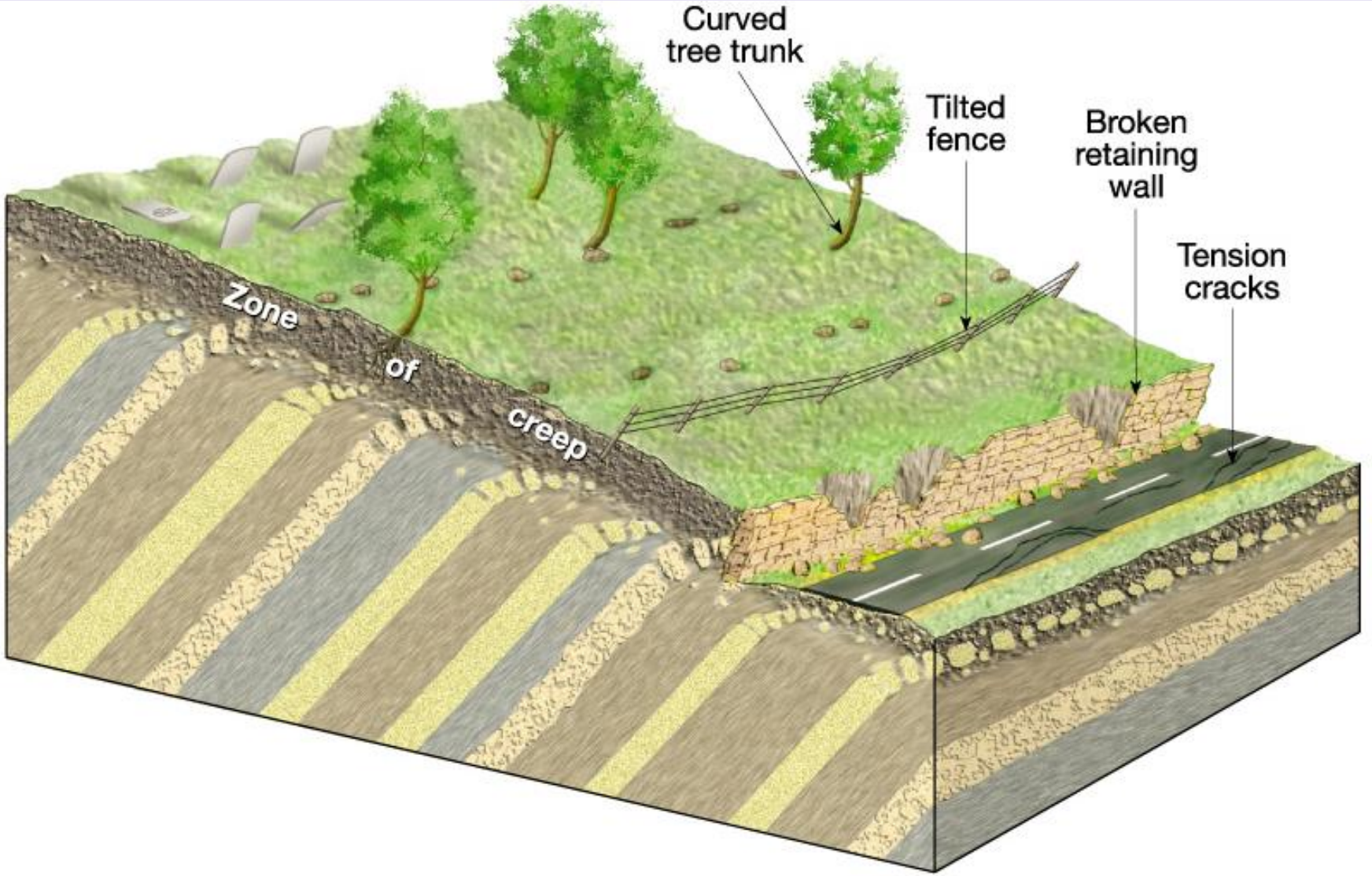
- **Scarp**
- **"Hummocky" terrain on and below (earthflow)**



Slump

- Earth moves on shallow, curved “fault”

Creep


Curved tree trunk
Tilted fence
Broken retaining wall
Tension cracks
Zone of creep

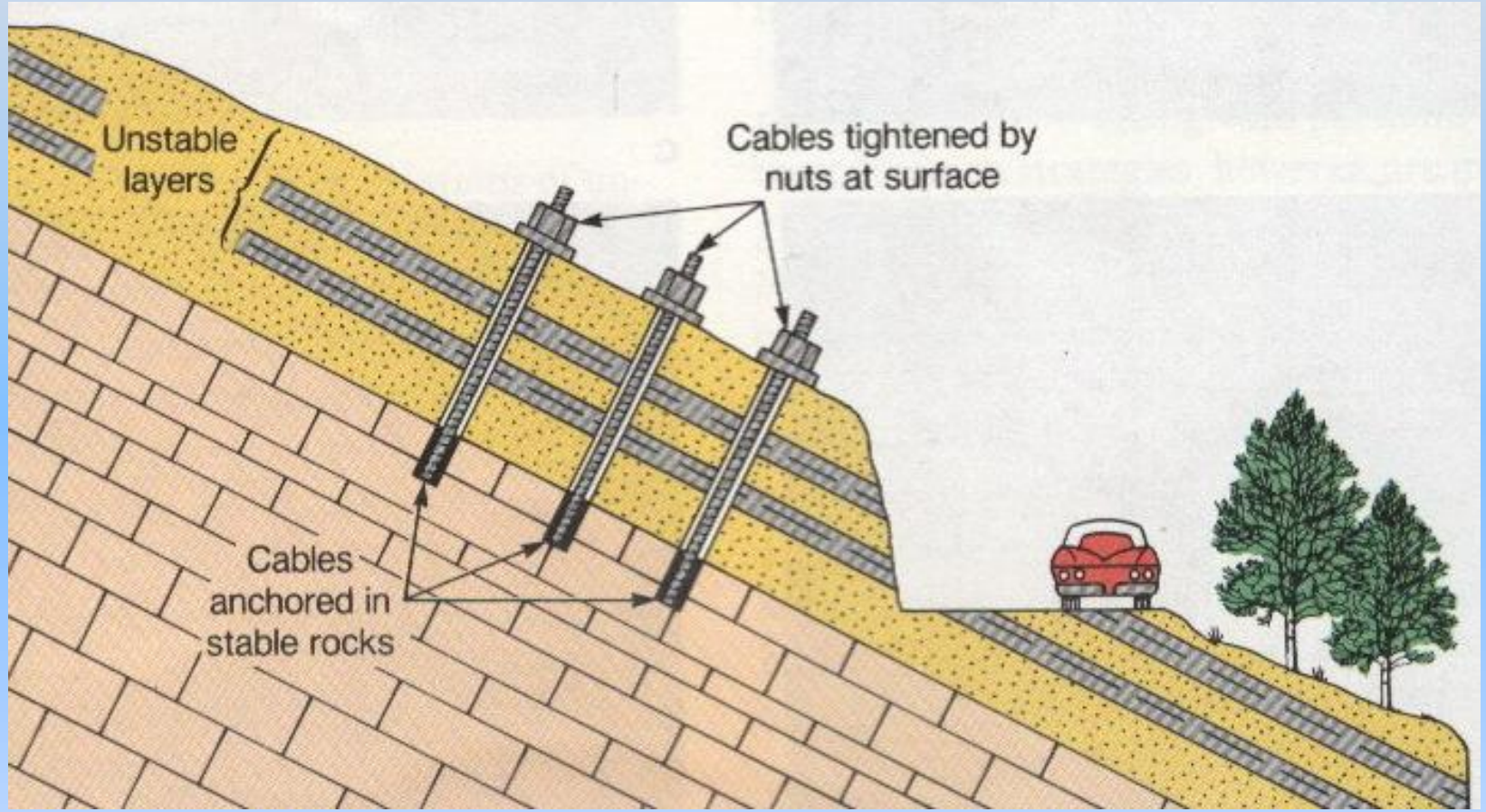
Preventing landslides

- Drains on a roadcut remove surface water from the cut before it infiltrates the slope

- Covering a slope with soil-cement to reduce infiltration of water and provide strength

Preventing landslides

- **Installation of rock bolts to stabilize a slope. (steel cables anchored in cement)**



(a)

(b)

A) Shallow slide in the early 1990s.

B) Retaining wall being constructed in 1999 to correct the problem.

C) Finished wall in 2001

(c)

Volcanoes

Volcanoes Destroy and Volcanoes Create

- More than 80 percent of the Earth's surface-above and below sea level-is of volcanic origin.
- Gaseous emissions from volcanic vents over hundreds of millions of years formed the Earth's earliest oceans and atmosphere, which supplied the ingredients vital to evolve and sustain life.
- Over geologic Eons, countless volcanic eruptions have produced mountains, plateaus, and plains, which subsequent erosion and weathering have sculpted into majestic landscapes and formed fertile soils .

What comes out of a volcano?

- Lava →
- Cinders →
- Ash →
- Gases →

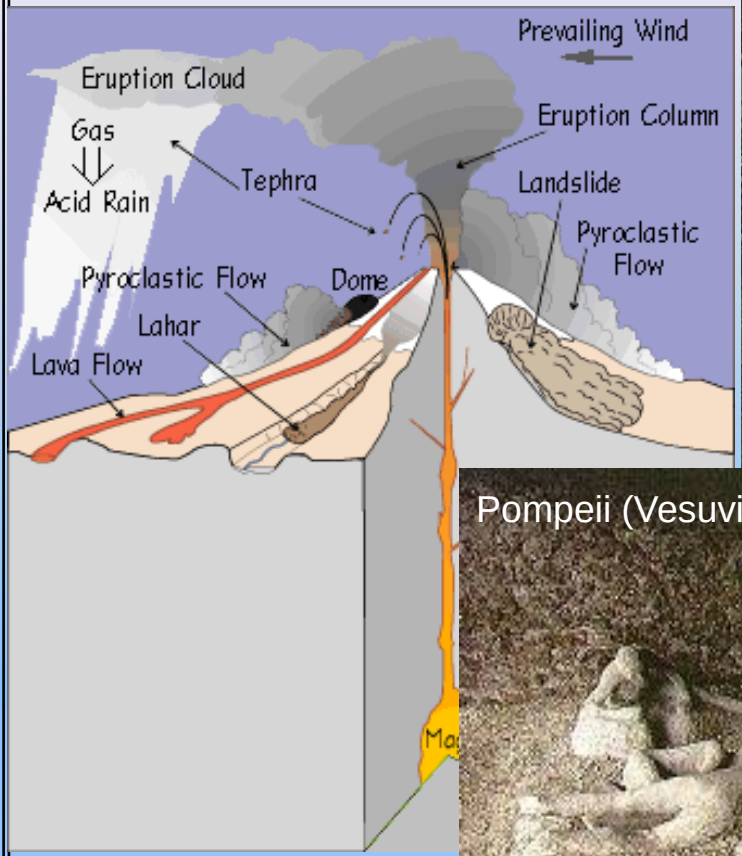
Types of Volcanoes

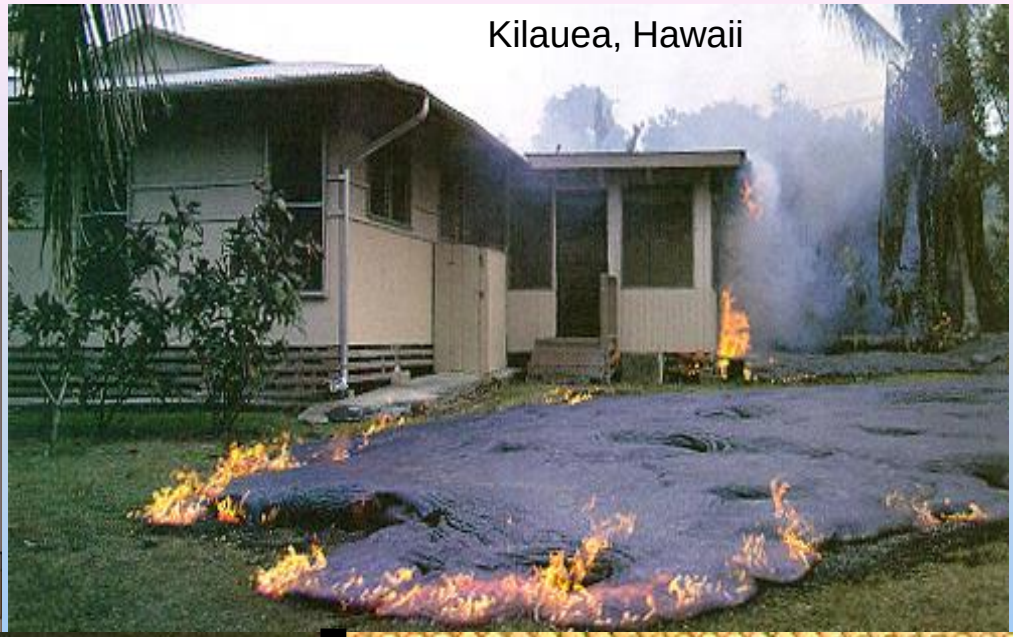
- **Shield volcano** – Mauna Loa, Hawaii
  - Broad
  - Slightly domed
  - Basaltic lavas
- **Cinder cone volcano** – Sunset Crater, Arizona
  - Small
  - Steep sides
  - Pyroclastic ejecta in the form of cinder cones
- **Composite volcano** – Mount St. Helens, Washington
  - Tall, large
  - Steep sides
  - Combination of lavas and pyroclasts

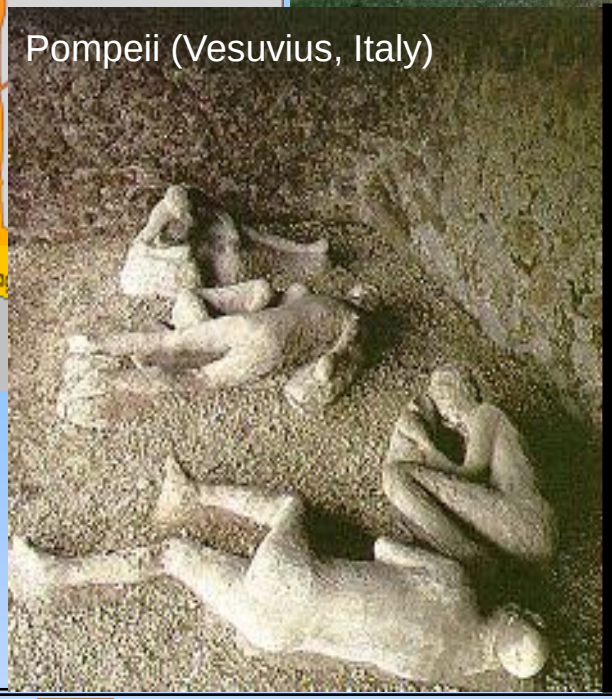
Types of volcanoes or volcanic deposits

The style of eruption of magma controls the shape of the volcanic deposits or edifice

Volcanic hazards




Kilauea, Hawaii


Pompeii (Vesuvius, Italy)


Pinatubo, Philippines

Lava flows

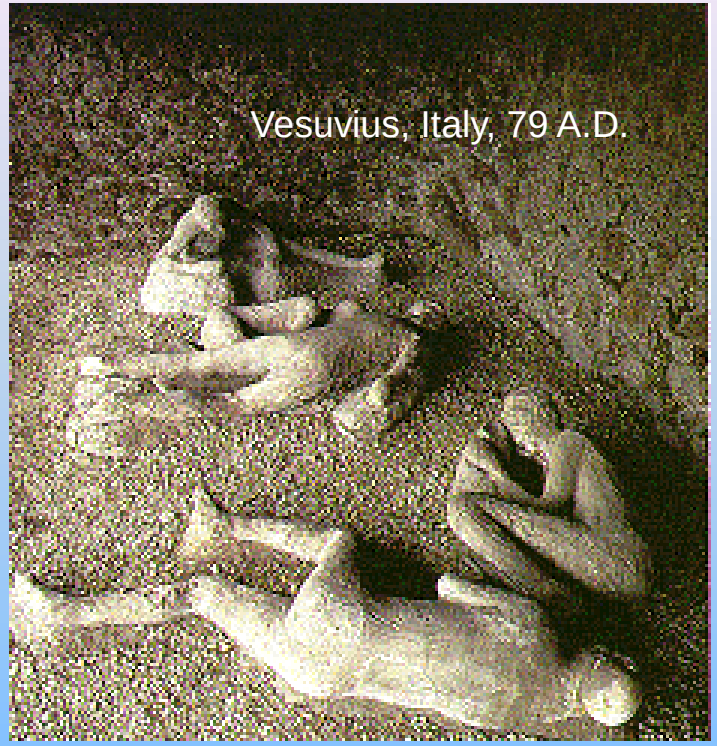
Lava flows are relatively predictable, so although they can cause substantial material damage, they represent a small threat to human life

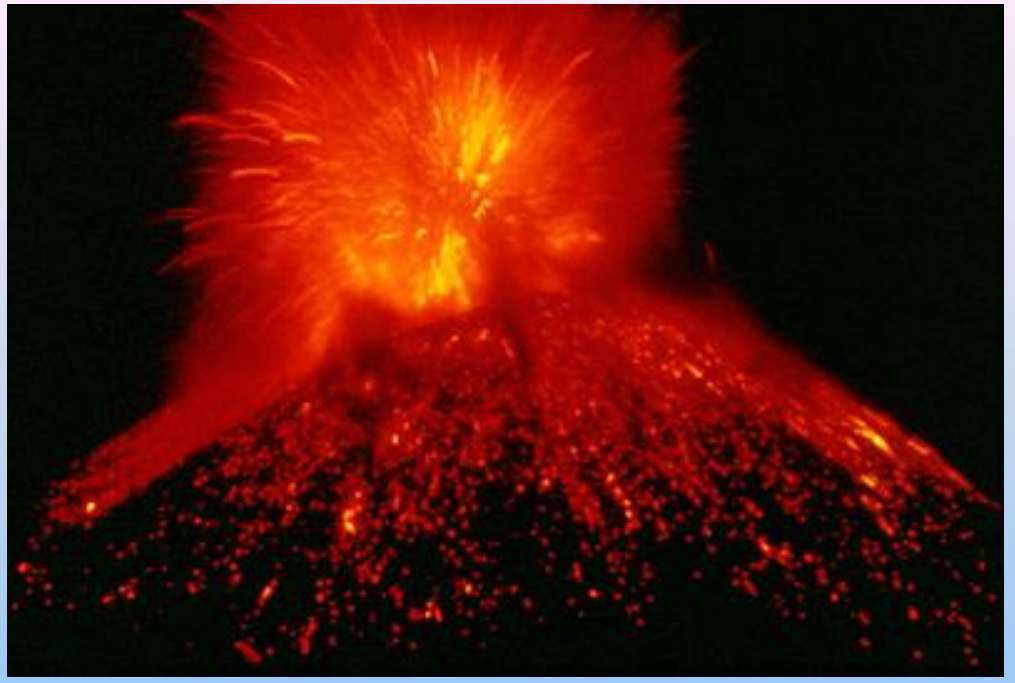

Heimaey, Iceland 1973

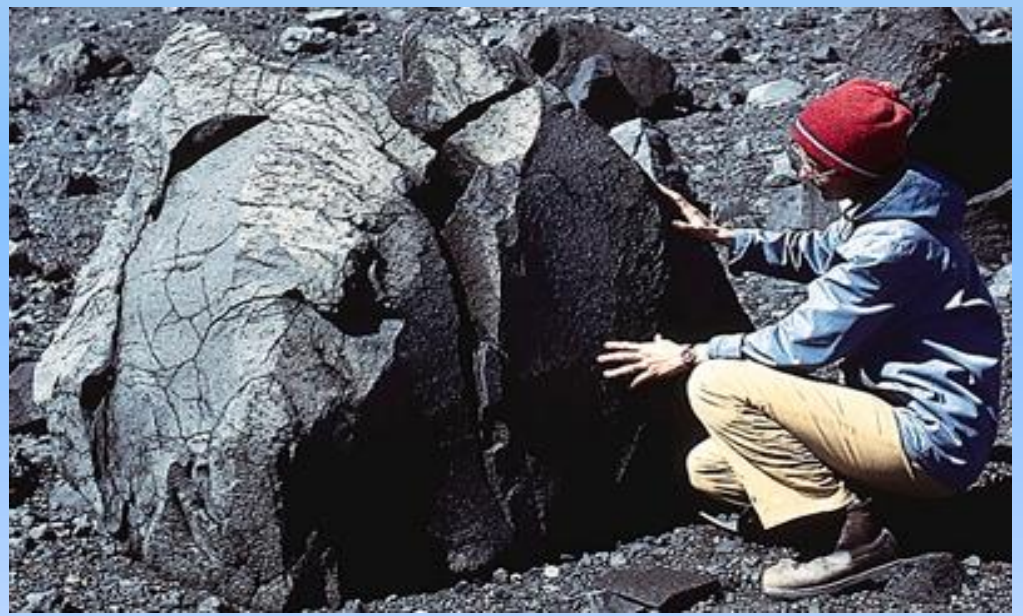

Kilauea, 1983-present


Kilauea, 1983-present

Tephra (pyroclastic falls)





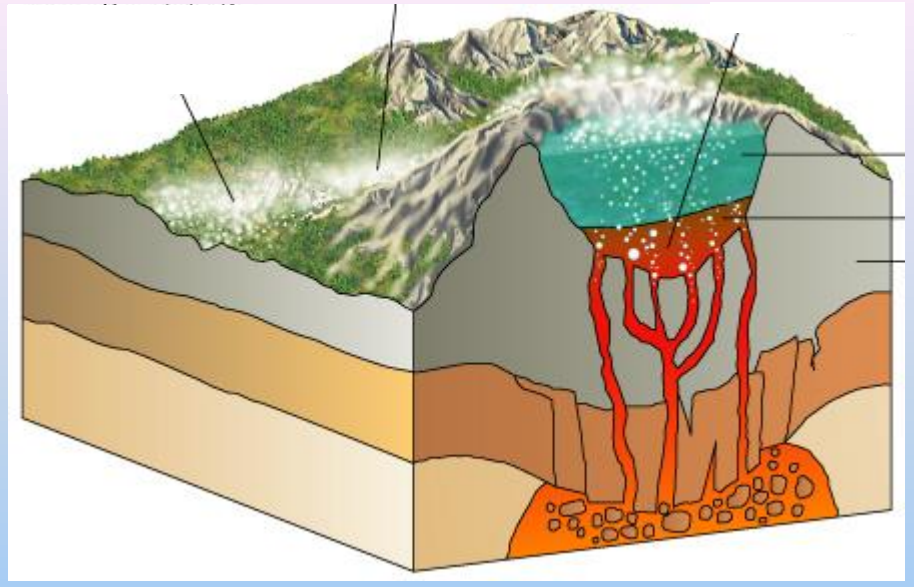


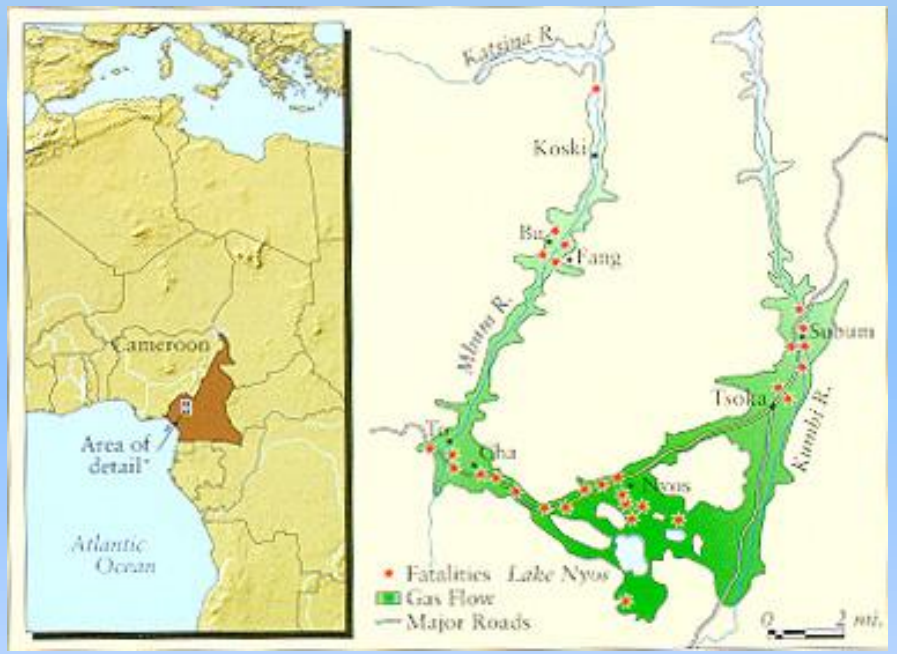
Pyroclastic **fallout particles reach sizes from less than a millimeter (*ash*) to several meters (*bombs*) in diameter.**

These fallouts can be very hot, as at Pompeii.

Toxic gases: Lake Nyos, Cameroon 1986

Volcanic CO2 accumulated in lake in the crater of the volcano was released due to disturbance of the lake, perhaps by earthquake, and CO2 clouds flowed down river valleys.
1700 people died of suffocation.





Volcanoes and Climate Change

- Giant eruptions spew material into stratosphere
- Ash encircles the globe for months or even years
- Can lower air temperatures world-wide
- Case study: Mount Pinatubo

Geological risk zones

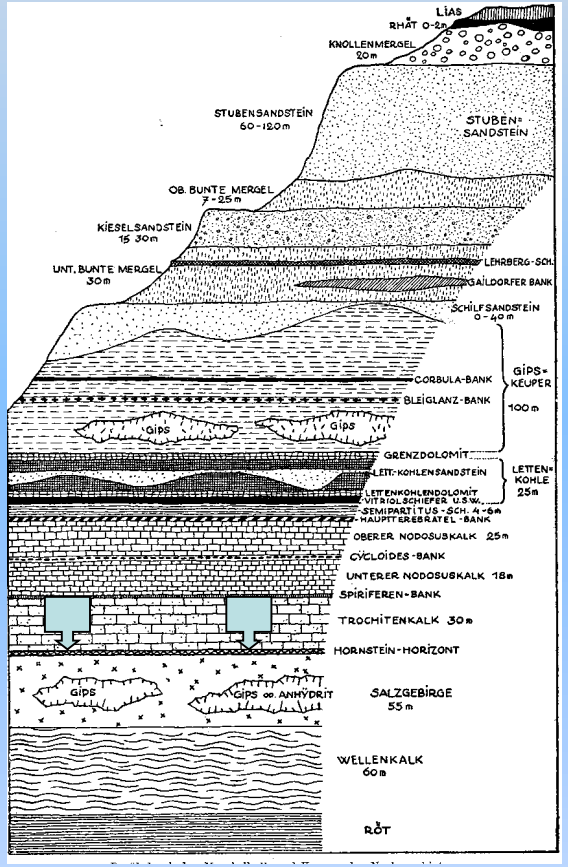
Earth quake zones
- Causes
- Global risk zones
- Examples

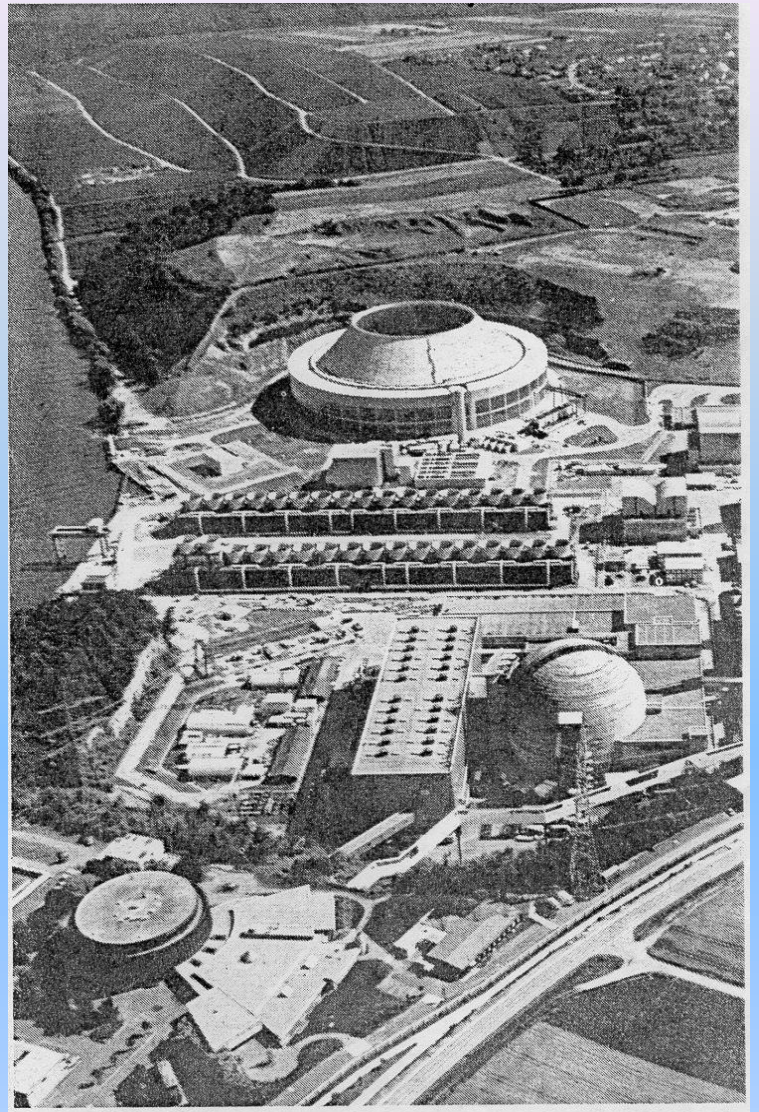
Consequences in planning
- Avoidance
- Earth quake safe buildings

Risk zones caused topography and by rock instability
- Dolines
- Gypsum / Anhydrite layers
- Mountain slopes

Nuclear power plant Neckar Westheim

The nuclear power plant is located in a geological risk zone:
Power house and cooling tower on different geologic shafts
Fundaments near to anhydrite layers





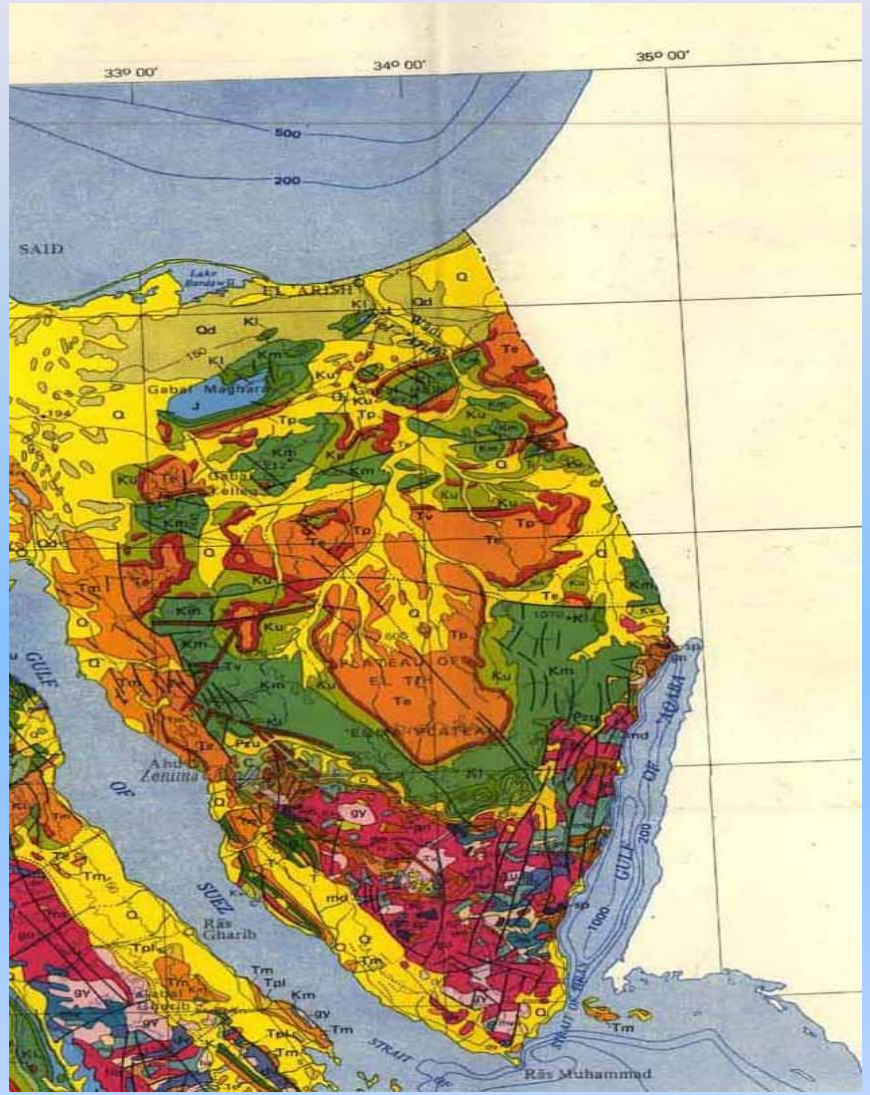
Von Anfang an auf unsicherem Boden: der Kühlturm des Kernkraftwerks Neckarwestheim – er versinkt allmählich im Boden. Foto: Krug

Stuttgarter Zeitung vom 14.07.1993

- **Geologic Mapping**
  - **Types & Illustrations of Geological Maps**

Geologic Mapping

- Geologic map is a precisely oriented, scaled down diagram of earth's surface or underground level in a mine
- Geologic maps are used for interpretation of Earth history.
- These maps show the distribution of geologic rocks, minerals, structural features, ores and of all ages presently exposed on earth surface.



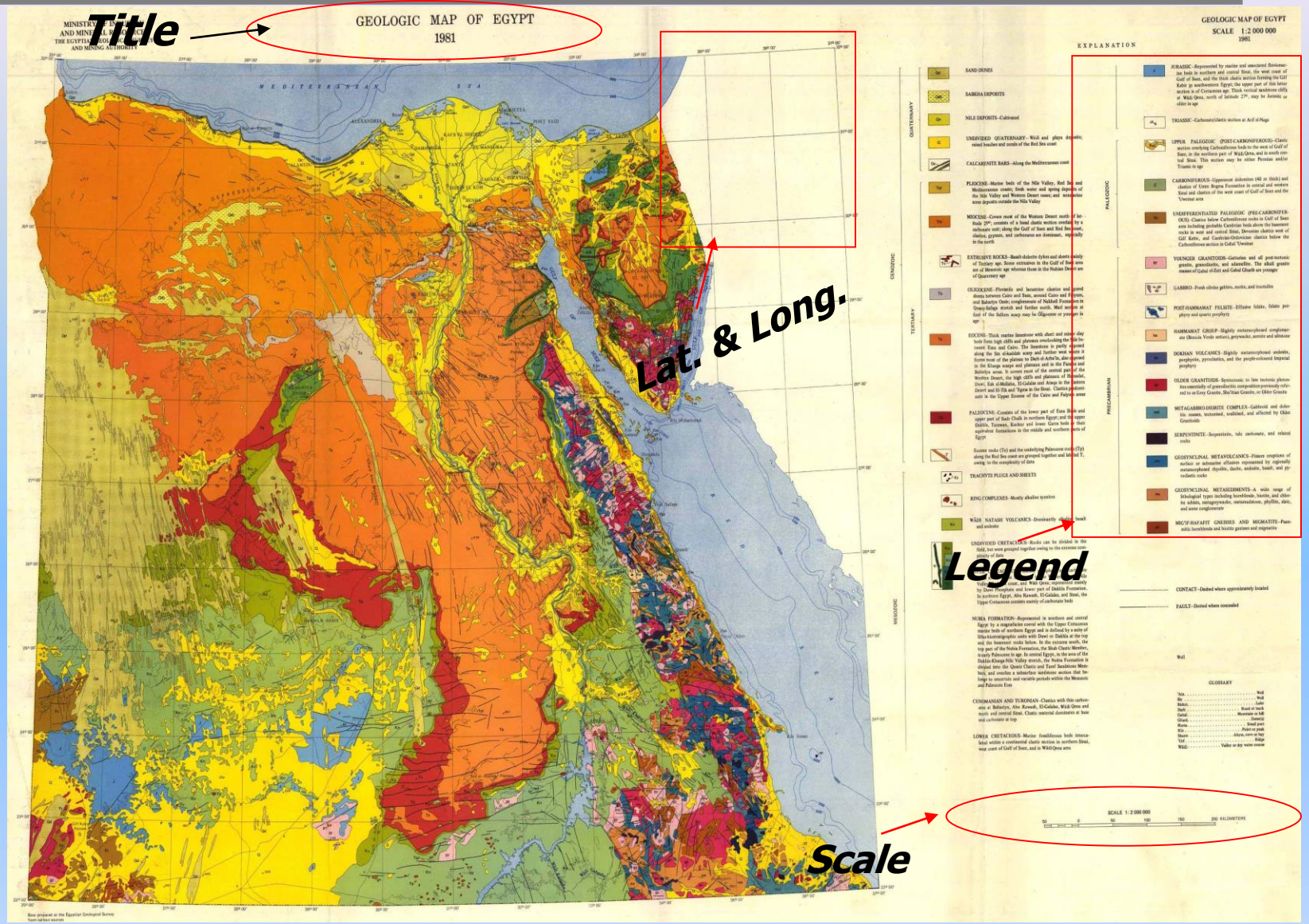
Types of geologic maps

- Geologic reconnaissance maps (1:250,000)
- Regional geologic maps (1:25,000)
- Detailed geologic maps (1: 10,000)
- Specialized maps (e.g. geochemical map, geophysical map, pleaogeographic maps, subsurface maps, mine maps, lithofacies maps…etc.

Illustrations on maps (Legend)

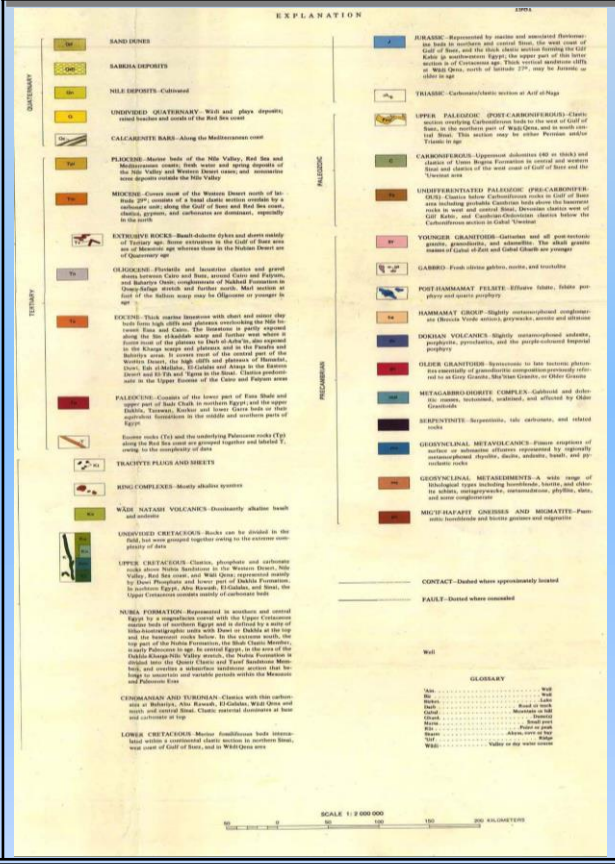
- Geographic name (Title)
- Geographic coordination *(Latitudes and Longitudes)*
- North direction
- Scale
- Rock units and geologic structures
- Geologic features (size, orientation,…)
- Age sequence of rock units
- Contour lines, symbols for waterways, roads, buildings, airports,…etc)

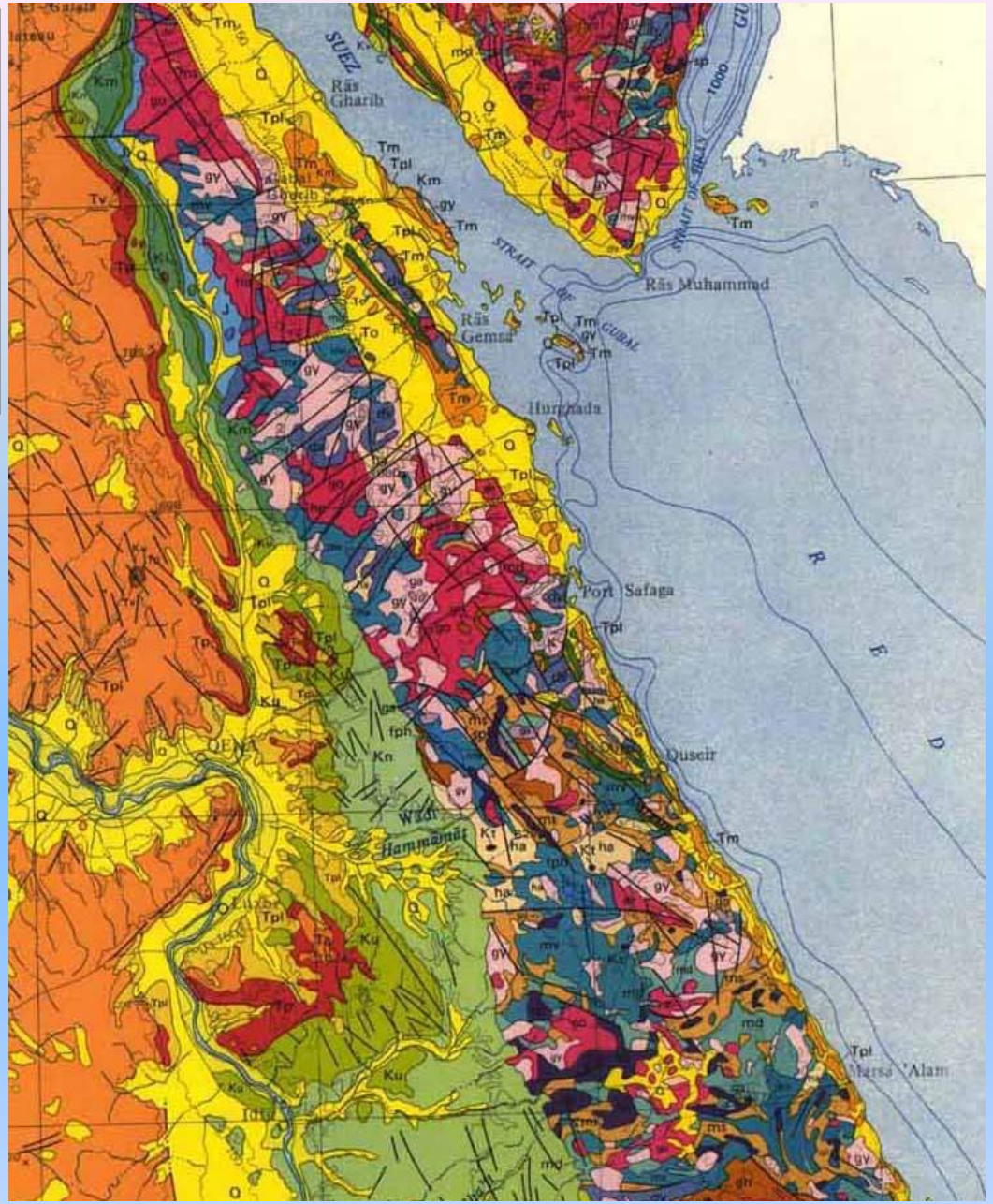
Geologic map



A.Prof.Dr. Mohamed Abd Elbaki, Ain Shams University, Geology Course

Geologic map of Ras Ghareb-Marsa Alam Area





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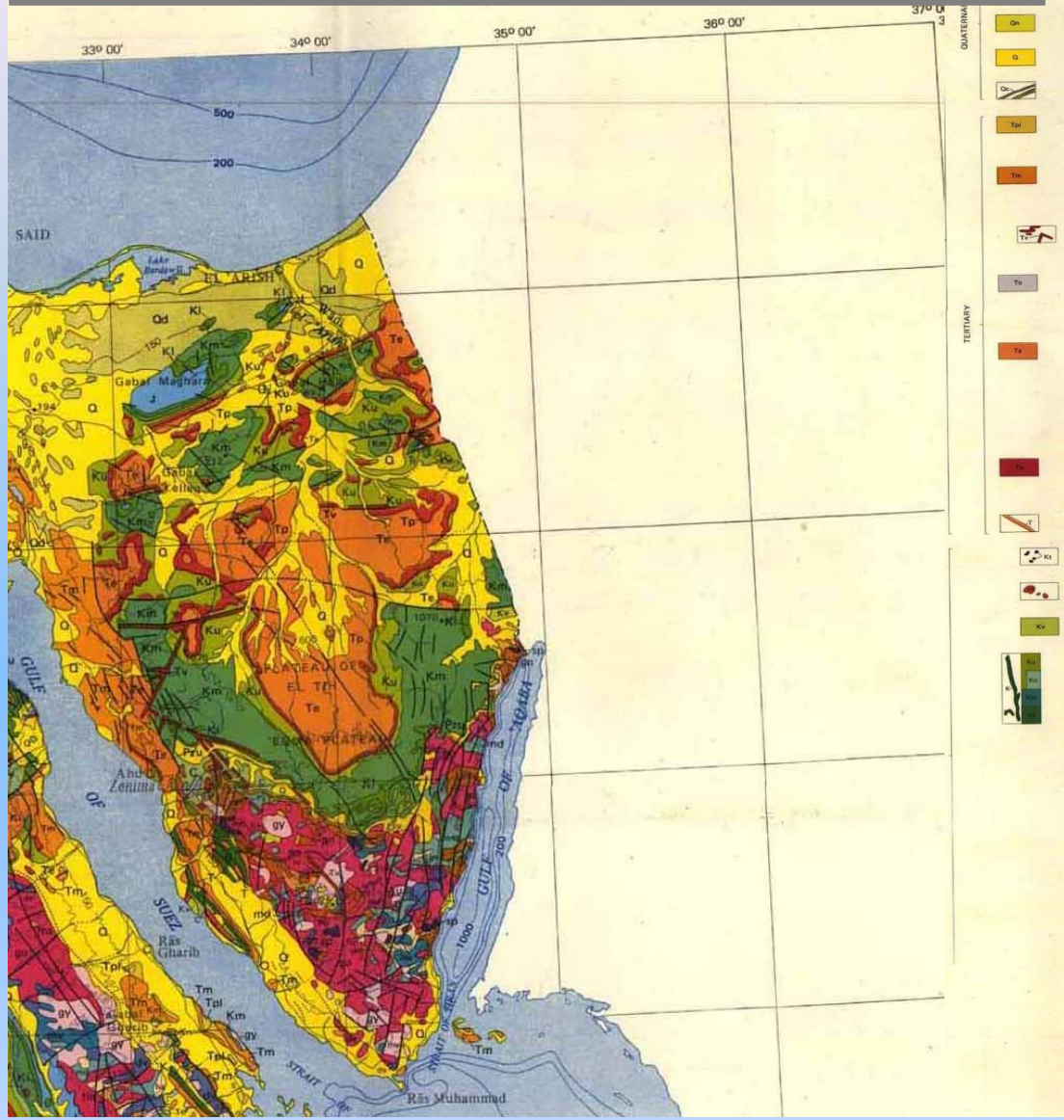
Field Mapping (Sinai)



GEOLOGIC MAP OF EGYPT
SCALE 1:2 000 000
1981

EXPLANATION

SAND DUNES

SABKHA DEPOSITS

NILE DEPOSITS—Cultivated

UNDIVIDED QUATERNARY—Wādi and playa deposits; raised beaches and corals of the Red Sea coast

CALCARENITE BARS—Along the Mediterranean coast

PLIOCENE—Marine beds of the Nile Valley, Red Sea and Mediterranean coasts; fresh water and spring deposits of the Nile Valley and Western Desert oases; and nonmarine scree deposits outside the Nile Valley

MIOCENE—Covers most of the Western Desert north of latitude 29°; consists of a basal clastic section overlain by a carbonate unit; along the Gulf of Suez and Red Sea coast, clastics, gypsum, and carbonates are dominant, especially in the north

EXTRUSIVE ROCKS—Basalt-dolerite dykes and sheets mainly of Tertiary age. Some extrusives in the Gulf of Suez area are of Mesozoic age whereas those in the Nubian Desert are of Quaternary age

OLIGOCENE—Fluviatile and lacustrine clastics and gravel sheets between Cairo and Suez, around Cairo and Fatyum, and Bahariya Oasis; conglomerate of Nakheil Formation in Qaser-Safaga stretch and further north. Marl section at foot of the Sallum scarp may be Oligocene or younger in age

EOCENE—Thick marine limestone with chert and minor clay beds form high cliffs and plateaux overlooking the Nile between Esna and Cairo. The limestone is partly exposed along the Sin el-kaddab scarp and further west where it forms most of the plateau to Dash el-Arba'in, also exposed in the Kharga scarps and plateaux and in the Farafra and Bahariya areas. It covers most of the central part of the Western Desert, the high cliffs and plateaux of Harnadat, Duwi, Eah el-Mellaha, El-Galalas and Ataqa in the Eastern Desert and El-Tih and 'Egma in the Sinai. Clastics predominate in the Upper Eocene of the Cairo and Fatyum areas

PALEOCENE—Consists of the lower part of Esna Shale and upper part of Sudr Chalk in northern Egypt; and the upper Dakhla, Tarawan, Kurkur and lower Gazra beds or their equivalent formations in the middle and southern parts of Egypt

Eocene rocks (Te) and the underlying Paleocene rocks (Tp) along the Red Sea coast are grouped together and labeled T, owing to the complexity of data

TRACHYTE PLUGS AND SHEETS

RING COMPLEXES—Mostly alkaline syenites

WĀDI NATASH VOLCANICS—Dominantly alkaline basalt and andesite

UNDIVIDED CRETACEOUS—Rocks can be divided in the field, but were grouped together owing to the extreme complexity of data

UPPER CRETACEOUS—Clastics, phosphate and carbonate rocks above Nubia Sandstone in the Western Desert, Nile Valley, Red Sea coast, and Wādi Qena; represented mainly by Duwi Phosphate and lower part of Dakhla Formation. In northern Egypt, Abu Rawash, El-Galalas, and Sinai, the Upper Cretaceous consists mainly of carbonate beds

NUBIA FORMATION—Represented in southern and central Egypt by a magnafacies coeval with the Upper Cretaceous marine beds of northern Egypt and is defined by a suite of litho-biostratigraphic units with Duwi or Dakhla at the top and the basement rocks below. In the extreme south, the top part of the Nubia Formation, the Shab Clastic Member, is early Paleocene in age. In central Egypt, in the area of the Dakhla-Khanga-Nile Valley stretch, the Nubia Formation is divided into the Qaser Clastic and Taref Sandstone Members, and overlies a subsurface sandstone section that belongs to uncertain and variable periods within the Mesozoic and Paleozoic Eras

CENOMANIAN AND TURONIAN—Clastics with thin carbonates at Bahariya, Abu Rawash, El-Galalas, Wādi Qena and north and central Sinai. Clastic material dominates at base and carbonate at top

LOWER CRETACEOUS—Marine fossiliferous beds interca-lated within a continental clastic section in northern Sinai, west coast of Gulf of Suez, and in Wādi Qena area

QUATERNARY

TERTIARY

JURASSIC—Represented by marine and associated fluviomarine beds in northern and central Sinai, the west coast of Gulf of Suez, and the thick clastic section forming the Gulf Kebir in southwestern Egypt; the upper part of this latter section is of Cretaceous age. Thick vertical sandstone cliffs at Wādi Qena, north of latitude 27°, may be Jurassic or older in age

TRIASSIC—Carbonate/clastic section at Arif el-Naga

UPPER PALEOZOIC (POST-CARBONIFEROUS)—Clastic section overlying Carboniferous beds to the west of Gulf of Suez, in the northern part of Wādi Qena, and in south central Sinai. This section may be either Permian and/or Triassic in age

CARBONIFEROUS—Uppermost dolomites (40 m thick) and clastics of Umm Bogma Formation in central and western Sinai and clastics of the west coast of Gulf of Suez and the 'Uweinat area

UNDIFFERENTIATED PALEOZOIC (PRE-CARBONIFEROUS)—Clastics below Carboniferous rocks in Gulf of Suez area including probable Cambrian beds above the basement rocks in west and central Sinai, Devonian clastics west of Gilf Kebir, and Cambrian-Ordovician clastics below the Carboniferous section in Gabal 'Uweinat

PALEOZOIC

YOUNGER GRANITOIDS—Gattarian and all post-tectonic granite, granodiorite, and adamellite. The alkali granite masses of Gabal el-Zeit and Gabal Gharib are younger

GABBRO—Fresh olivine gabbro, norite, and troctolite

POST-HAMMAMAT FELSITE—Effusive felsite, felsite porphyry and quartz porphyry

HAMMAMAT GROUP—Slightly metamorphosed conglomerate (Breccia Verde antico), greywacke, arenite and siltstone

DOKHAN VOLCANICS—Slightly metamorphosed andesite, porphyrite, pyroclastics, and the purple-coloured Imperial porphyry

OLDER GRANITOIDS—Syntectonic to late tectonic plutonites essentially of granodioritic composition previously referred to as Grey Granite, Sha'itian Granite, or Older Granite

METAGABBRO-DIORITE COMPLEX—Gabbroid and dioritic masses, tectonised, uralitised, and affected by Older Granitoids

SERPENTINITE—Serpentinite, talc carbonate, and related rocks

GEOSYNCLINAL METAVOLCANICS—Fissure eruptions of surface or submarine effusives represented by regionally metamorphosed rhyolite, dacite, andesite, basalt, and pyroclastic rocks

GEOSYNCLINAL METASEDIMENTS—A wide range of lithological types including hornblende, biotite, and chlorite schists, metagreywacke, metamudstone, phyllite, slate, and some conglomerate

MIG'IF-HAFAFIT GNEISSES AND MIGMATITE—Psammitic hornblende and biotite gneisses and migmatite

PRECAMBRIAN

CONTACT—Dashed where approximately located

FAULT—Dotted where concealed

Well

GLOSSARY

'Ain . . . . . Well
Bir . . . . . Well
Birket . . . . . Lake
Darb . . . . . Road or track
Gabal . . . . . Mountain or hill
Gharb . . . . . Dune(s)
Marsa . . . . . Small port
Ra's . . . . . Point or peak
Shatm . . . . . Abyss, cove or bay
'Urf . . . . . Ridge
Wādi . . . . . Valley or dry water course

SCALE 1: 2 000 000
50 0 50 100 150 200 KILOMETERS