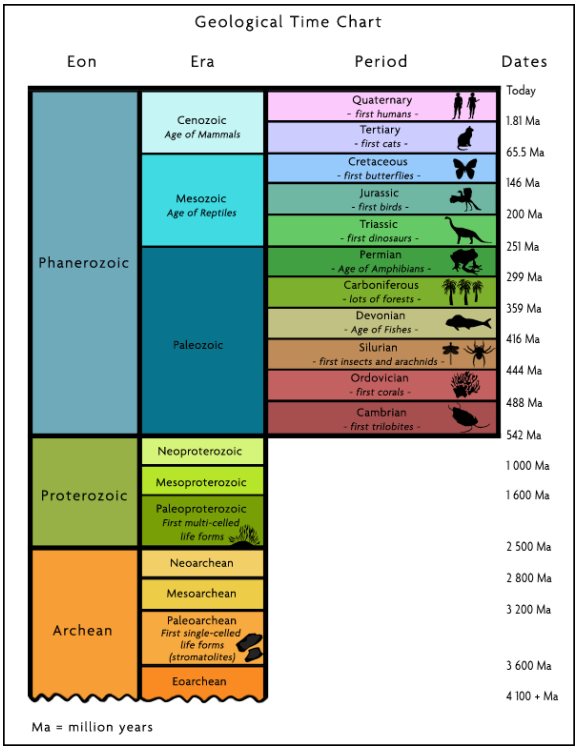
EESC101 Lecture notes

Week one – Geoscale, time and fossils

Time scale



Define rocks

Rocks are an aggregate of minerals.

- **Igneous** rocks form from molten material (cooled magma) When igneous rocks are broken into sediments, they can be packed together for form sedimentary rocks.

- **Sedimentary** rocks are those that have formed through the deposition and solidification of sediment.
- **Metamorphic** rocks form when existing rocks are changed by pressure and/or temperature.

How do we determine time/age in geoscience?

- **Relative age:** The age of one geological feature compared to another.
- **Absolute age:** The numerical age (specified in years, GA, MA etc)

Principle of uniformitarianism

Physical processes we can observe operating today also operated in the past, at comparable rates. The present is the key to the past.

Principle of original horizontality

Sediments on earth are deposited as flat horizons, due to the gravity of earth.

Principle of superposition

In a sequence of sedimentary layers, each layer is younger than the layer beneath.

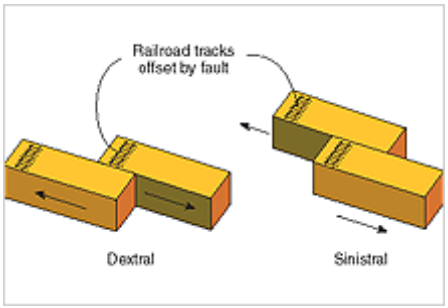
The principle of cross-cutting relations

If one geological feature cuts across another, the feature that has been cut is older

Unconformities

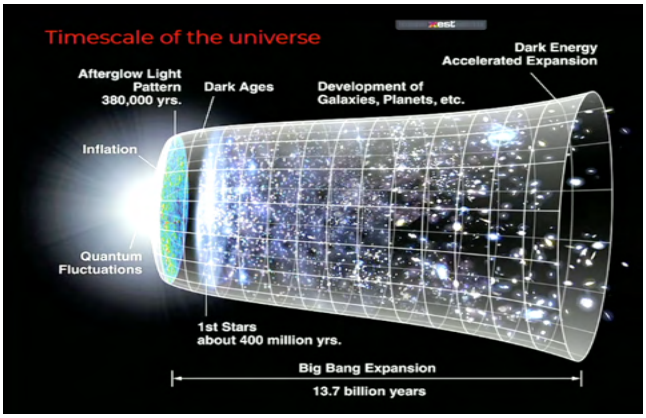
A boundary two rocks units where one layer was eroded and/or new strata were not deposited. A gap in geo time recorded by rock record.

Sinistral vs dextral in fault lines



Week two – beginning of life on earth

How old is the earth relative to our universe?



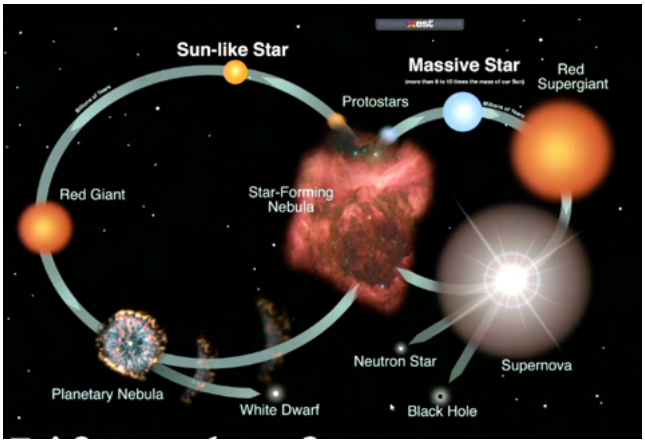
The universe is 13.7 billion years
Our galaxy = Milky way
First stars 400million years ago
Earth is 4.5billion years old. Or 4.55 GA

How our stars formed?

Sun like star

- Mainly made of hydrogen and helium

- Star forming nebula > Protostar >sun like star (Burn, die, and form>) Red Giant > planetary nebula/ white dwarf.



Massive star

- Star forming nebula > Massive star > Red supergiant > Supernova > Black hole/neutron star.

Exploding stars formed majority of the elements in the periodic table, including those elements that we ourselves are made of. Big bang and star dust!

How our solar system formed?

- Protosun in the middle. Protoplanetary disk with rock, ice and space dust, which circled around the sun. As they came closer together
- 1/3 age of the universe, our solar system started to form. Approx 4.56 billion years ago. We knew this from tracking meteorites.

Inner solar system: rocky giants
Outer solar system: Gas and ice giants

How did earth form?

Accretion – As particles move around, they bump in together and come together. Gravity field developing. Matter begins to pull in matter around them.
Differentiation- Once a mass is achieved, the heavier minerals migrate to the centre (iron) and the lighter elements go to the surface (silica crust)
Impacts – Molten earth hitting other molten rocky masses. Eg. Proto-earth hitting Theia, more mass coming together. Also formed the moon.

How come heavy minerals like gold didn't fall to the middle of the earth like iron?
Perhaps because they were brought to the earth by meteorites later in time.

Craters age?
Perfect spherical shape = younger craters.
Crater on top of/within another crater = Crater beneath is older.

The geological record from meteorites
Comet: A chunk of ice and rock from the outer solar system.
Asteroid: A rock in orbit.
Meteoroid: A rock that's bigger than dust but smaller than asteroid.
Meteor: A meteoroid that enters earth's surface and begins to burn
Meteorite: A meteor that hits the earth's surface.

- Most meteorites are believed to have come from the asteroid belt.

Meteorites three main types:
Iron meteorites: Nickel -iron-alloys
Stony meteorites: Silicate minerals (no iron)
Stony-iron meteorites: silicates with nickel-alloys, and Iron matrix

First evidence for our atmosphere and life on earth
- Amino acids present in stony meteorites (life came to earth)
- Amino acids created by Urey-miller experiments (life originated on earth)

- Stromatolites: Formed 3.7 billion years ago. Law of uniformitarianism. Contain cyanobacteria (algae) which produced oxygen for the first time. This oxygen was needed to produce banded iron formations.
Banded iron formations precipitated from Earth's early oceans as oxygen + iron → iron oxide minerals.
- Black vents: in the ocean produced iron. The oxygen (from stromatolite) and iron bonded together and then became trapped at the bottom of the ocean (banded iron formation – red and black band like look)> Ocean became iron depleted, and became blue instead of red/purple.

Week three – Minerals and their chemistry

What are minerals, diversity and importance

To be a mineral, a substance must:

- Naturally occurring on earth, not man made. Cannot be made by animals either.
- Inorganic (coral and tree branches are not minerals)
- Must have a distinct chemical formula (repeatable recipe)
- Must be arranged in an orderly atomic structure (Crystal structure)

Use of minerals

- Table salt
- Cosmetics (natural sparkles)
- Mobile phone
- Steel – banded iron formations help provide materials
- Lithium in drugs and batteries
- Fertilisers (phosphate)

How many minerals?
Over 4000, but about 40 are abundant.

Silicate minerals make up 75% of the Earth's crust.
Three examples are: (i) Plagioclase feldspar (ii) Quartz (iii) Orthoclase feldspar

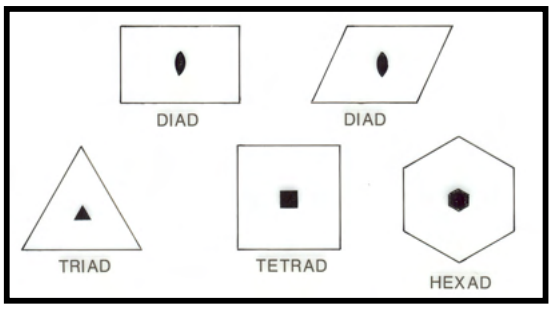
Mineral grains vs crystals
- A mineral has a crystalline structure, but no well-formed crystalline faces or terminations.
- A crystal is a well formed solid, with naturally forming crystal plane faces and terminations.

How can we distinguish between minerals based on physical properties?

- Colour: Transparent: no colour, which come from impurities. Opaque: Colour is from light reflecting of surface
- Streak: Scraping a mineral on a ceramic plate. The crushed powder left behind shows colour.
- Lustre: The way a mineral surface scatters light. Pearly, greasy, dull, silky, metallic, vitreous (glassy), adamantine (transparent)
- Hardness: the scratching resistance of a mineral, linked to the atomic bond strength.
- Specific gravity: mass/volume. How heavy?
- Other: Taste, ductility- draw into wire, malleability – pound into sheers, elasticity, feel, smell, magnetism.
- Habit, cleavage/fracture – how they break, and crystal system.

Symmetry

Symmetry: Occurs about a:
Point: Centre
Line: axis
Plane: Mirror plane
e.g. a cube has 3 tetrad axes ($3A_4$)



Axis of symmetry = axis of rotation
Rotational symmetry: when we rotate an object, it appears the same every time.
In a complete revolution (360^0) around the axis, the crystal reaches equivalence:
2 times (diad axis; i.e. every 180^0 rotation)
3 times (triad axis; i.e. every 120^0 rotation)
4 times (tetrad axis; i.e. every 90^0 rotation)
6 times (hexad axis; i.e. every 60^0 rotation)

7 crystal systems and their defining elements of symmetry (some have many symmetry elements):

Triclinic - no axes of symmetry;

Monoclinic - 1 diad (A_2) axis;

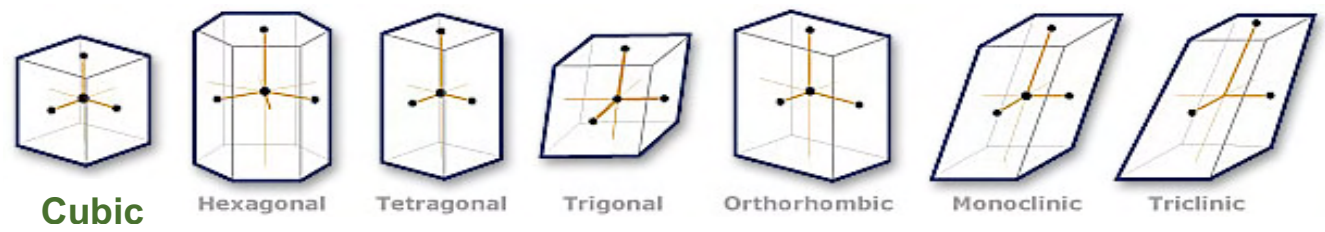
Orthorhombic - 3 diad (A_2) axes;

Trigonal - 1 triad (A_3) axis (other axes also possible);

Hexagonal - 1 hexad axis (A_6) (other axes also possible);

Tetragonal - 1 tetrad (A_4) axis (other axes also possible);

Cubic - 4 triad (A_3) axes (plus other axes).



Habit, cleavage and fracture in minerals

Habit: outside shape of a mineral. Eg. Cube, hexagonal, trigonal.
Cleavage: braking into a predictable 2D plane of structural weakness. Eg breaking chocolate in the designed break points.