

**Learn questions:**

These questions can be answered often with few words, as you will see.

The best is to draw a small figure for most of the questions instead of writing long essays.

All questions but one in the exam will be taken from here.

Q1: Rock classification

What is:

Granite

Basalt

Plutonite

Volcanic rock

Metamorphic rock

Sedimentary rock

Etc.

α ✓ Q2: You need to learn the Streckeisen diagram (top half) for volcanic and plutonic rocks.

α ✓ Q3: The classification diagram of clastic sedimentary rocks needs to be studied (after Pettijohn – the so-called ‘toblerone’ plot in the notes, nothing else)

Q4: I will give you some mineral names and you tell the igneous rock:

**example:**

quartz, alkalifeldspar and muscovite

you answer: granite

α ✓ Q5: You need to know when the following Earth periods, eons and eras start and end: Archean, Proterozoic, Phanerozoic, Paleozoic, Mesozoic and Cenozoic and Quaternary, Jurassic, Cretaceous, Triassic, Paleogene

✓ Q6: You need to be able to classify sedimentary rocks in organic, chemical and clastic and volcanoclastics.

Organic: *Peat, lignite, Plant coal*  
 Vol: *Tuffs, lignite → ~~coal~~*  
 α ✓ Q7: What is a rock, mineral and element?

chemical: *carbonates, sulphates, Limestone, chert*

✓ Q8: You need to name a certain number of minerals.

*Quartz, plagioclase, alkali feldspar, amphibole, biotite, pyrite*

✓ Q9: What is a heavy mineral?

*Mineral with density > 2.8 g/cm<sup>3</sup>*

α ✓ Q10: What is magma and what is lava?

α ✓ Q11: What is the famous Bowen reaction series about? Explain and draw a sketch.

✓ Q12: Since when plants do exist on earth? *410 Ma*

Q13: Name a sedimentary rock representing clastic sediments, chemical sediments and biological sediments. *Clastic: sandstone* *chemical: carbonate*

*biological: Mudrock*

Q14: Classify sedimentary rocks according to their composition and genesis.

Tgallite - Volcanic - clastic

Imbricate

Tuff

Toba, Tambora

✓ Q15: Name 4 **well-known** volcanoes elsewhere in the world.  
Mt. St. Helens, Mount Vesuvius, Krakatoa, Eyjafjallajökull, Mt. Pelee, Thera, Mt. Etna, Mt. Fuji

✓ Q16: Name one mountain belt each in Africa, Australia, South America, Asia and North America, Europe. Atlas, Musgrave Ranges, The Andes, Himalaya, Rocky mountains, The Alps

✓ Q17: What is metamorphism? ~~is~~ solid state transformation of pre existing rock to another by the means of hot fluids, pressure and high temperature

Q18: What is a syncline and what is an anticline?

✓ Q19: How old is the earth?  $4,55 \text{ Ga} = \underline{4550 \text{ Ma}}$

Q20: What is a normal and reverse fault? and explain the difference to a thrust.

Q21: What is a syncline, anticline and monocline?

### 'Know' questions:

Here you will get sketches to label or you can draw easily a figure and label the different parts to make yourself understandable.

✓ Q1: Age relations of sedimentary rocks, folding and intrusion. You will get a picture and label and explain what happened.

✓ Q2: Why some minerals are stable and resistant against transport and weathering and others not? Bonding between atoms determines the characteristics of the minerals.  
Structure

✓ Q3: How do you differentiate, in a hand sample, volcanic and plutonic rocks?

Volcanic: smooth surface - rapid cooling  
Plutonic: coarse grains - slow cooling

✓ Q4: Draw and explain very short what a pyroclastic flow (ignimbrite) is!  
Ash that has collapsed and fallen down, sliding down the side of the volcano

✓ Q5: Explain chemical and physical weathering very short and with a sketch.

Q6: How does a carbonate rock form? Organic/non-organic grains, matrix - cementation, sedimentary

Q7: What are gravity flows? is fluid or sediments moving due to the gravity flows alone

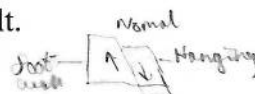
Q8: How ripples are formed? Irregularities in bottom sediment lead to ripples. Flow over bedform  
Asymmetric = flow direction symmetric = tidal areas also wind.

✓ Q9: Draw the Hjulström diagram and explain why mud is so exceptional.

Q10: How do you identify metamorphism in a hand sample? Foliation, texture, preferred mineral orientation  
Size of crystals - direction same (sorted)

✓ Q11: What you use to identify a carbonate in the field or hand sample? HCl, saltysyr

✓ Q12: Draw and label a normal and reverse fault.



Q13: When occurs folding?

Q14: What typical tectonic setting controls the earthquake activity in Chile? What is the reason for earthquakes in California or Haiti? *Subduction zone in Chile (convergent plate boundary) Transform boundary in Haiti or California (transform fault, San Andreas)*

Q15: Draw very rough and sketchy a trilobite, bivalve, graptolite, sea urchin, brachiopode, coral, ammonoidea as such that they are clearly identifiable.

✓ Q16: What is a supercontinent? Name two. *(Exin base)*

*Pangea, 250Ma, Columbia or MUSA 1.8-1.7 Ga*

Q17: A large meteorite hit the earth at the end of the Cretaceous (65 Ma) and probably forced the extinction of dinosaurs. How can you identify the exact sedimentary layer of this event? *Much iridium (longanin matter)*

Q18: Draw and label a subduction zone with the arc region and the adjacent basins.

Q19: Name a rock, its **main** mineral and the dominant element in this mineral.  
example:  
granite-quartz-silica (Si)

**Think!:**

Q1: Several sedimentary rocks are differentiated in clastic and chemical rocks. Why rounded grains can be found in clastic sedimentary rocks? *Transported long distance before deposition (quartz)*

Q2: Why most of the crystals are elongated and not round or small and round?

Q3: Why would you study a volcanic rock in a sedimentary succession where oil is found? *Easy to date. To determine the age of the sedimentary rock in which it was found. Which helps to pinpoint future finds*

Q4: You work in an area where your sedimentary rock is host to petroleum but the age of deposition of the sediment is unknown. A granite intrudes this rock. Why study the granite? *Sedimentary rock deposited first. Study radioactive minerals in granite to determine age. Our sedimentary rock is a bit older - could say same age.*

✓ Q5: Why is it important to study grain sizes and grain forms in clastic sedimentary rocks? *Porosity, permeability*

Q6: Why only few fossils can be found in conglomerates? *Size in building blocks. Not anoxic or rapid burial, will be decomposed quickly*

Q7: Why do you find tropical plants in Paleozoic rocks in Antarctica?

Q8: Why do you find Carboniferous glacial rocks today in North Africa?

Q9: Why is it easier to fold a carbonate than a granite? *Hardness, do not crack - easier to bend carbonate*

Q10: Why is it easier to weather a clay or mudrock than a quartz-arenite? *Hardness (bonding type)*

Q11: Why would you propose a course about microfossils for petroleum geologists? *Carbonates are important w/ microfossils. Most oil reservoirs are found in carbonates.*

Q12: Why are dinosaurs relatively unimportant for geologists and palaeontologists in general? *Wide lifespan*

Q13: Explain why Norway is an excellent example to demonstrate that we are in an icehouse time ( a cold time) and what are the effects of glaciations and deglaciations for sealevels and the continents

Sea level was higher before  
now lower. Because accumulated in ice

Easy to see sealevel changes

## Learn questions:

Q1

Granite – plutonic, mainly quartz, alkalifeldspar, muscovite

Basalt – volcanic, (oceanic crust)

Plutonite – plutonic,

Volcanic, fine grained igneous rock formed during quick cooling of lava above surface.

Metamorphic, solid state transformation, see Q17

Sedimentary rock: Rock formed by deposition of sediments at surface or within bodies of water.

Igneous rocks: Plutonic, volcanic and subvolcanic rocks.

Q2, Q3, eget ark

Q4

Granite = quartz, alkalifeldspar, mica (muscovite)

Basalts = plagioclase, pyroxene, olivine

Andesite = plagioclase, pyroxene, hornblende

NB! Felsic: over 63% silica, intermediate: 52-63% silica, mafic: 45-52% silica, ultramafic: under 45% silica

Q5

Archean: 3,8 (3,6) – 2,5 Ga

Proterozoic: 2,5-0,542 Ga

Phanerozoic: 542-0 (today) Ma

Paleozoic: 542-245 Ma

Mesozoic: 245-65,5 Ma

Cenozoic: 65,5-0 Ma

Triassic: 251-200 Ma

Jurassic: 200-145,5 Ma

Cretaceous: 145,5-65,5 Ma

Paleogene: 65,5-23,03 Ma

Quaternary: 2,588-0 Ma

- Precambrian 4567,17-542 Ma

Q6

Clastic sedimentary rocks: are composed of silicate minerals and rock fragments that were transported by moving fluids. Conglomerates and breccias from gravel, sandstones from sand, and mudstone from mud.

Organic: Are generated when organisms use materials dissolved in air or water to build their tissue.

Limestone

Chemical: Forms when mineral concentration in solution become supersaturated and inorganically precipitate.

Volcaniclastic: Clastic sedimentary rocks which has fragments of volcanic rocks. Ex Ignimbrite.

NB: Hard to classify!

Q7

Elements form minerals, minerals form rocks.

Rock: A coherent, natural occurring solid, consisting of minerals.

Mineral: Minerals are made of elements, and form rocks, and therefore most of the solid earth.

Naturally occurring, mostly inorganic, chemical compounds.

Element: Cannot be divided into other substances, using conventional chemical methods.

Q8

Quartz, plagioclase, amphibole, muscovite, biotite, pyrite, calcite, pyroxene, olivine++

Q9

Heavy: density above 2,8 g/cm<sup>3</sup>

Q10

Magma: Molten or semi molten rock that's below the surface of the Earth. Melt + residue = parent magma

Lava: Magma above the surface. Erupted by volcanoes.

Q11

Bowen reaction series: Showing how the sequence of fractional crystallization of a melt could lead to the formation of different magmas.

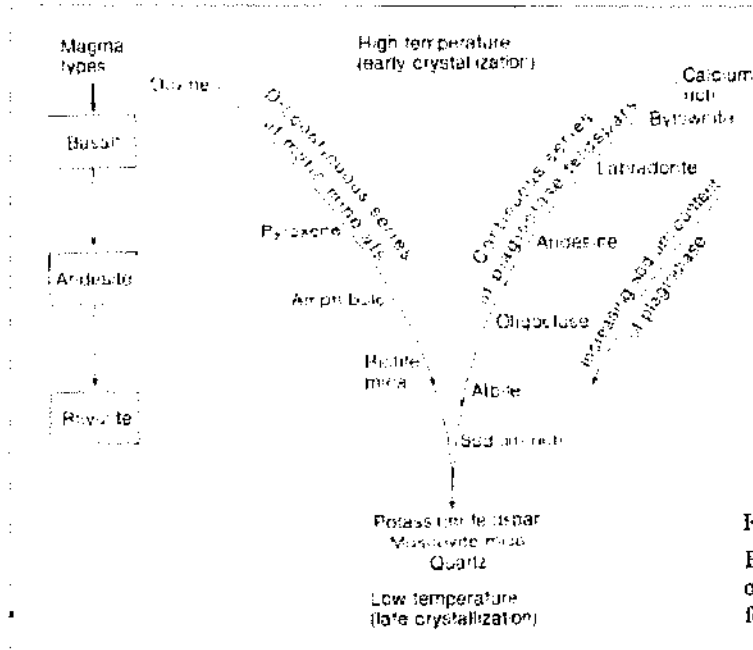


Figure 15-8

Bowen's reaction series, showing how the sequence of fractional crystallization of a melt could lead to the formation of differentiated magmas.

Q12

Plants have existed since 410 Ma

Q13

Clastic: Sandstone, conglomerate

Chemical: Limestone, chert

Biological: Limestone, coal

Q15

Mt. Saint Helens, Mt. Vesuvius, Eyjafjallajökull, Mt. Fuji, Mt. Pelee, Toba

Q16

Africa: Atlas mountains

Australia: Musgrave range

South America: The Andes

Asia: Himalaya

North America: Rocky Mountains

Europe: The Alps

Q17

Solid state transformation of pre existing rock to another, by the means of (hot fluids), pressure and high temperature.

Q18

Syncline: Fold with younger layers closer to the centre of the structure.

Anticline: Fold that is convex up and has its oldest beds at its core.

Monocline: Is a step like fold in rock-strata consisting of a zone of steeper dip within an otherwise horizontal or gently dipping sequence.

Q19

Earth is 4550 Ma old

(earliest life, 3583 Ma)

Q20

Thrust is reverse fault with small angle (gently dip).

**Know**

Q1

Remember: Tilting, intrusion (dyke / sill), folding, faulting, erosion (unconformity) ++

Q2

Some minerals are stable and resistant against transport and weathering because of the bonding type between the atoms in the mineral. Bonding type determines the characteristics of the minerals. Also the structure of the atoms decides how resistant they are.

Q3

Volcanic has a smooth surface (fine grained) due to rapid cooling. Crystals don't have time to grow. Plutonic has coarser grains / larger crystals than the volcanic because of slower cooling. Crystals grow.

Q4

Pyroclastic flow is superheated ash (gas / rock) that the volcano erupts. The ash collapses and falls down, sliding down the side of the volcano. Speed of the flow depends of the gradient of the slope and the volcanic output rate.

Q5

That is to know the porosity and permeability

Q6

Precipitation of chemicals and microfossils (biologic life).

Organic and non-organic grains, matrix, cementation.

Consist of carbonate minerals, precipitated from water. Also small fossils.

Q7

Gravity flows are fluid or sediments moving due to the gravity forces alone.

Q8

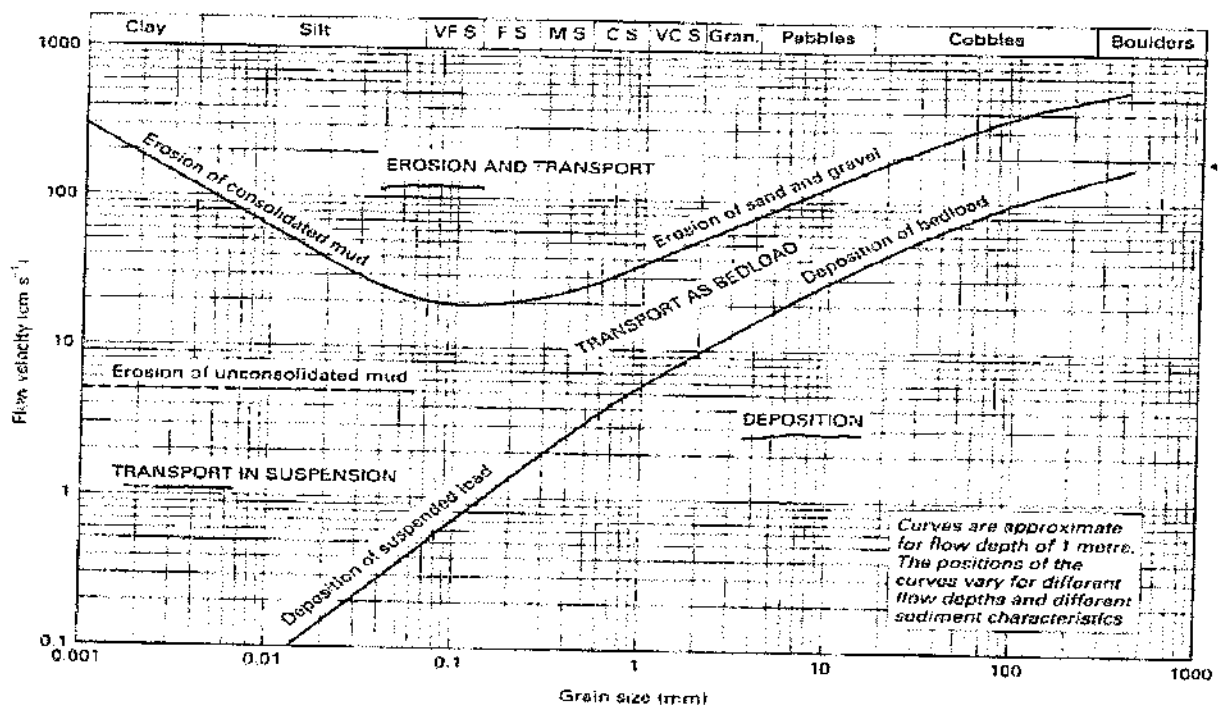
Ripples are formed by irregularities in bottom sediment. Flow over bedform.

Asymetric ripples indicate flow direction.

Symetric ripples are formed in tidal areas.

Q9

Mud is exceptional because higher flow velocity needed for clay and silt (fine), than ex fine sand, due to frictional forces between the particles, clump together.



Q10

Identify foliated texture. Flat, "squished" looks.

Q11

Carbonates bubbles when acid is poured on. Ex use HCl.

Q12

Normal and reverse fault. Remember steep angle on reverse fault, low angle on thrust.

Footwall, hangingwall.



Q13

Folding occurs when sediments are exposed of stress. Ex a reverse fault where sediments only bend, but not break. Convergent setting.

Folds form under varied conditions of stress, hydrostatic pressure, pore pressure, and temperature - hydrothermal gradient, as evidenced by their presence in soft sediments, the full spectrum of metamorphic rocks, and even as primary flow structures in some igneous rocks.

Q14

Chile: Convergent tectonic setting (subduction zone).

Transform boundary in California of Haiti. (San Andreas fault, transform fault)

Q15

Fossils, eget ark

Q16

Supercontinents are extra large continents, consisting of more than one continental core.

Ex Pangea and Columbia (Nuna).

Q17

This sediment layer will contain much iridium.

Q18

Subduction zone. Remember forearc basin, volcanic arc, back arc basin. Slab pull.

Q19

- Granite – Quartz – Silica (Si)
- Basalt – Pyroxene – Iron (Fe) – *Plagioclase - Ca*
- Andesite – Plagioclase – Kalsium (Ca)
- Syenite – Alkalifeldspar – Sodium (Na)

**Think**

Q1

Rounded grains has been transported long distance (by liquid) before compaction to a rock.

Q2

Because of the structure of the molecules and atoms in the minerals

Q3

To determine the age of the sedimentary rock in which it was found, which helps to pinpoint future finds. If it is ash, then aerially extensive, and short term event like a volcanic eruption, it forms a time line in the sedimentary rock.

Q4

Sedimentary rock was deposited first. Study the radioactive minerals in the granite to determine the age. We then know at least how old the sedimentary rocks are.

Q5

Porosity and permeability

Q6

Animals need to be buried under certain conditions to fossilize. Rapid burial and anoxic environment is needed. Conglomerates start life as a mass of shingle or pebbles which is later compacted and cemented by the percolation of water. Any animal that died under these conditions would quickly decompose. However, you can find "reworked" fossils in conglomerates. These are animals that died millions of years earlier, then the rocks in which they were fossilized broke away (through erosion) and became part of a conglomerate.

Q7

Because of plate tectonics. Greenhouse period.  
In the Paleozoic, Antarctica was located near equator.

Q8

Because of plate tectonics. One continent in the carboniferous, and rocks has been transported, before the plates rifted apart.

Q9

Hardness.. Carbonates are soft, and does not crack so easily, layering. Easier to bend.

Q10

Quartz arenite consists of about 95% quartz. Quartz is very hard, and the hardest mineral to weather. This is because of the bonding type between the atoms in the quartz mineral. Mudrocks consists of much matrix (more than 75%), and is easier to weather than the quartz-arenite.

Q11

Microfossils are a very useful tool for correlating depositional systems in many of the major oil and gas domains of the world.  
In complex sand and shale depositional systems, it is difficult to correlate for any distance based on lithology. To know where the drill is in a stratigraphic order.

Q12

They lived over a too wide time span.

Q13

Sea level changes are easy to spot. Now much of the water is stored as glaciers or icebergs, and that makes sea level go down. Also thermal expansion of the sea is greater when we are in a greenhouse time, which makes sea level rise.

Answer:

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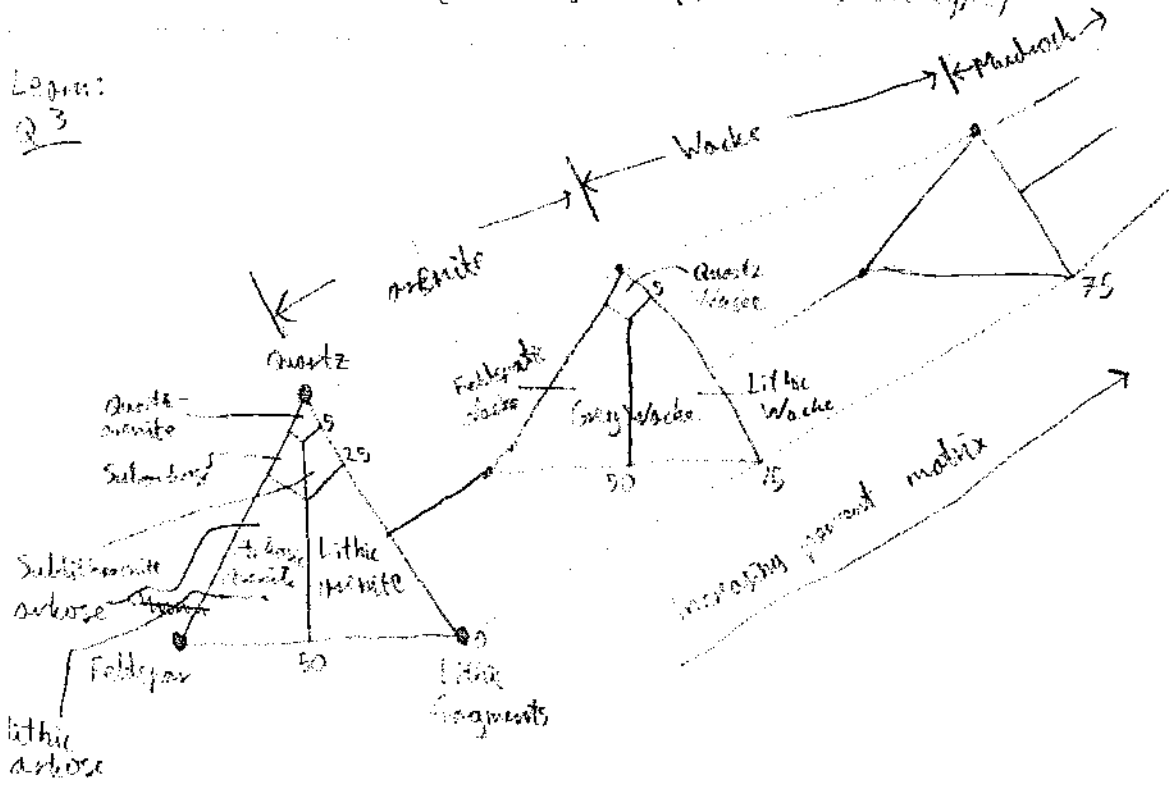
Physical: Weathering by physical forces (frost, water, temperature, ...) break down or reduce a rock to smaller and smaller fragments.

Chemical: Weathering with chemical reactions (hydration, oxidation, carbonation, ion exchange).

Transition rocks and minerals into new chemical compounds that will remain without further change under conditions prevailing at or near the surface.  
e.g. dissolution of calcium carbonate by carbonic acid (see redox rxn.)

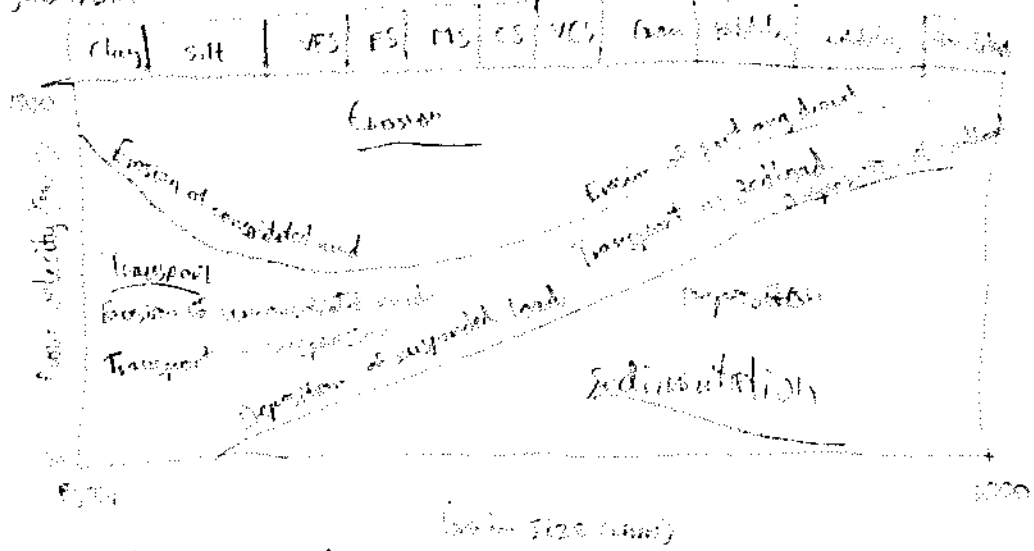
Sketch: (Chemistry change, minerals, rock type)

Lehrer:  
Q 3



Q9 Know

Hydrology



NB: Higher flow velocity needed for clay and silt to be in suspension because of their small size and high surface area.

Q5: Archean: 3.6 → 2.5 Ga  
 Proterozoic: 2.5 → 0.542 Ma  
 Phanerozoic: 542 Ma → Today  
 Paleozoic: 542 → 245 Ma  
 Mesozoic: 245 - 65 Ma

Cenozoic: 65 → 0 Ma  
 Quaternary: 1,922 → 0 Ma  
 Jurassic: 200 → 145.5 Ma  
 Cretaceous: 145.5 → 65.5 Ma  
 Triassic: 251 → 200 Ma  
 Paleogene: 65.5 → 23.03 Ma

Q7

Rock: A coherent, naturally occurring solid, consisting of minerals.

Mineral: Minerals are made of elements and form rocks and therefore most of the solid earth. (Naturally occurring, mostly inorganic, chemical compounds)

Element: Cannot be divided into other substances, using conventional chemical methods.

Elements form minerals, minerals form rocks

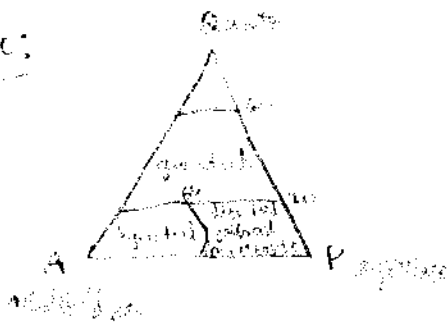
Q10

Magma = molten rock that's below the surface  
 (hotly molting etc) + gradual cooling with time

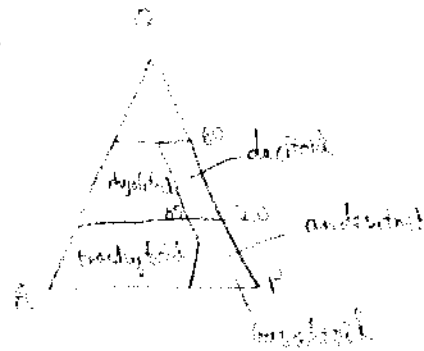
Lava: Magma above surface, molten rock, still moving

Q9

Plutonic:



Volcanic:

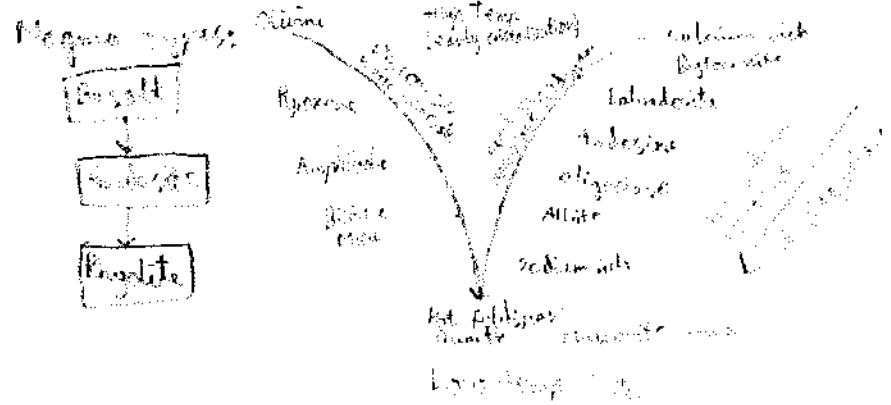


Granite, Diorite, Basalt

Andesite, Basalt, Diorite

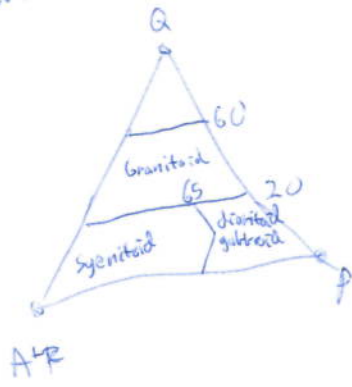
Q11:

Bowen's reaction series, showing how the sequence of fractional crystallization of a melt could vary with composition of different magmas.

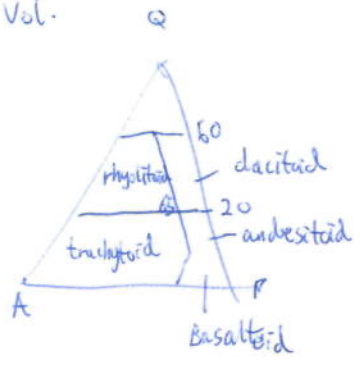


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Plut.

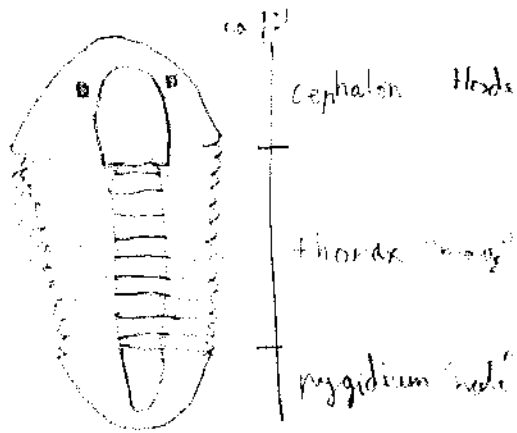


Vol.



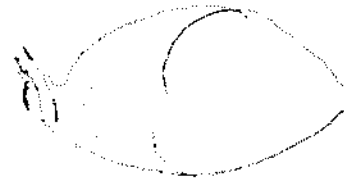
Sedimentary rocks: *Carboniferous* - *Permian* - *Triassic* - *Jurassic* - *Cretaceous* - *Tertiary* - *Quaternary*

Trilobite:

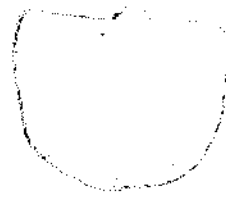


Bachopoda:

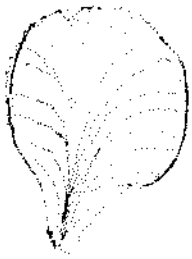
Zoo:



Amphibia

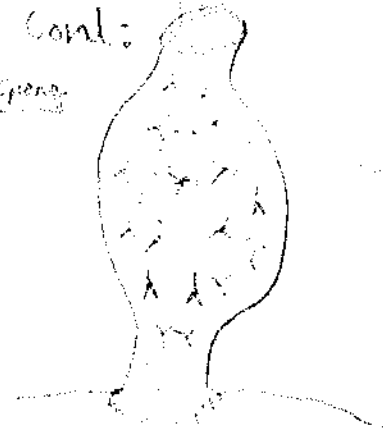


Bivalvia:



Cond:

Spore



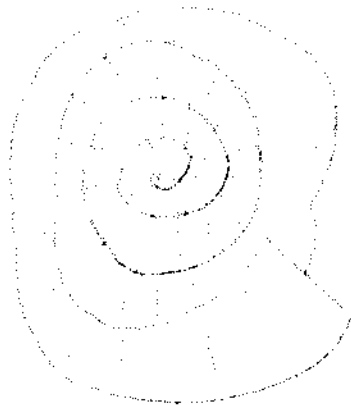
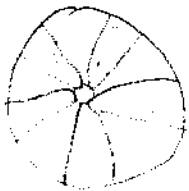
Living water

Scyphozoa:



Ammonoidea

Sea urchins:



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