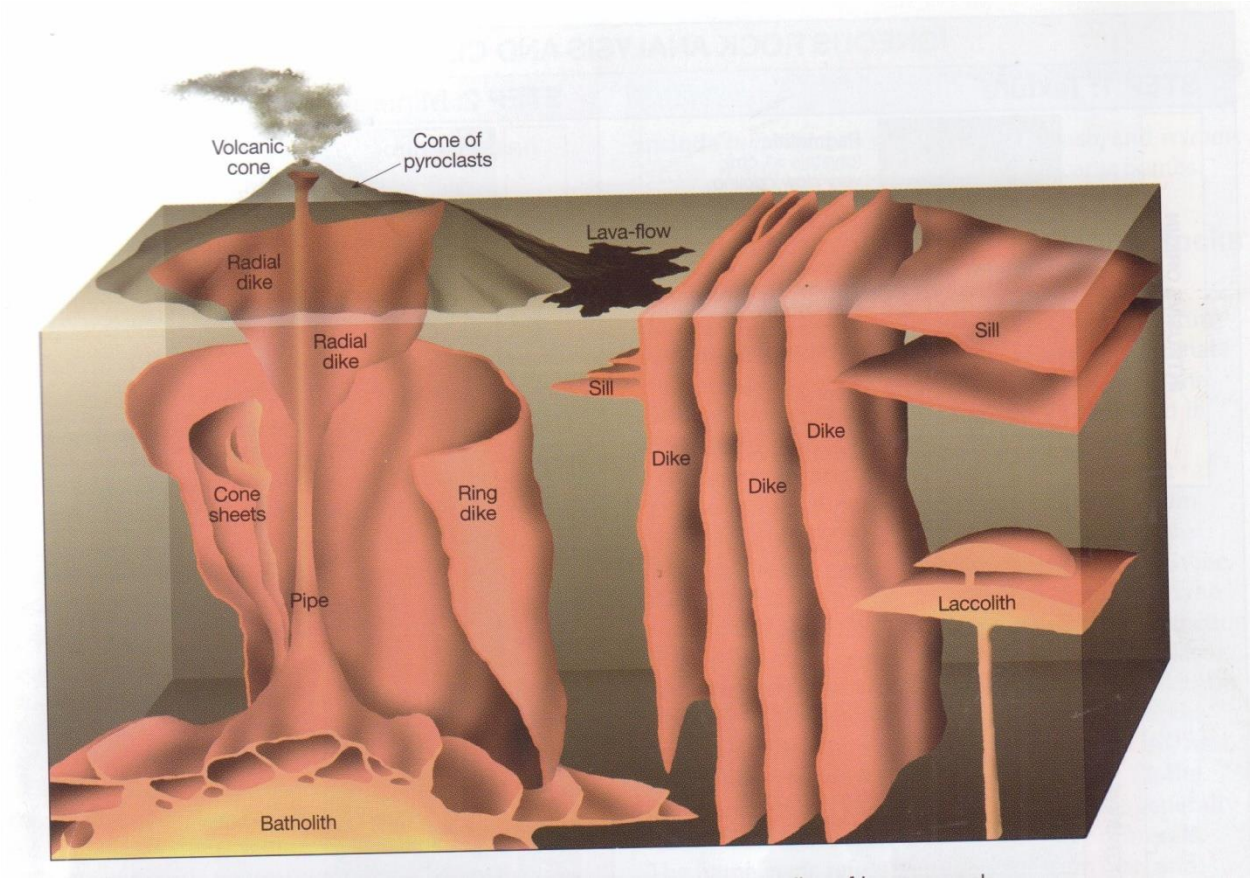
Modes of Occurrence of Igneous Rocks

One of the first things to determine about an igneous rock is the place of its formation: whether below or at the ground level. Extrusive (volcanic) rocks are formed by the flow of lava on the preexisting surfaces and the intrusive (plutonic) rocks crystallized within the preexisting rocks beneath the earth's surface. Sometimes, on the basis of field studies, the third category of hypabyssal rocks can be added. They were formed in the shallow parts of the crust either being closely associated with the true volcanic rocks or forming of-shoots from the bigger plutons. From the point of view of petrographer there are not distinctive criteria to recognize the hypabyssal rocks under the microscope: most of them (wide spread basalts) fell within the volcanic rocks, some of them (diabases, lamprophyres, kimberlites) reveal textures characteristic rather for plutonic rocks. Thus, combining the field and microscopic observations one can deal with three groups of igneous rocks (coarse, medium, fine grained or plutonic, hypabyssal and volcanic), whereas for the microscopist only two groups (volcanic and plutonic rocks) exist.



Main types of intrusive and extrusives bodies of igneous rocks\

Taking into consideration the shape of intrusive bodies and their relationship with the surrounding (country) rocks the following types of intrusions can be distinguished:

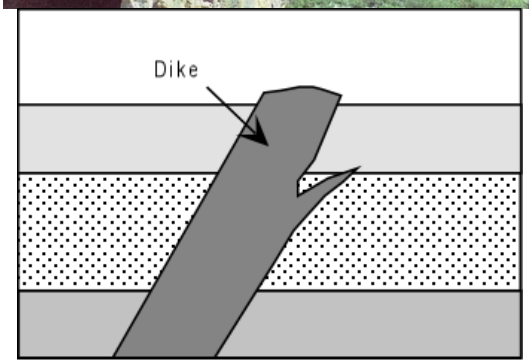
A. sheet intrusions,

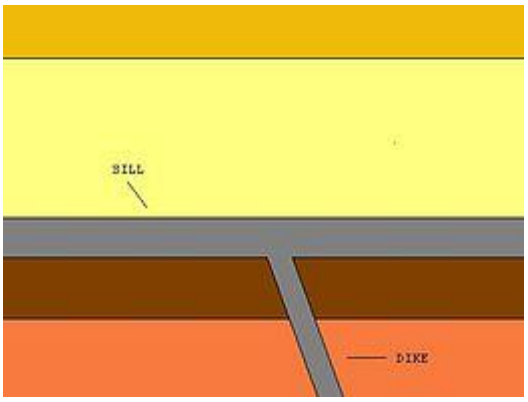
B. lens-shaped intrusions

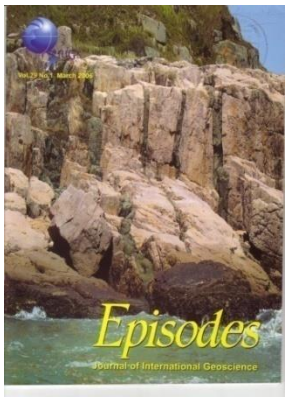
C. subjacent plutons.

Ad A. Within this group there are dikes and sills respectively discordant and concordant bodies against country rocks.

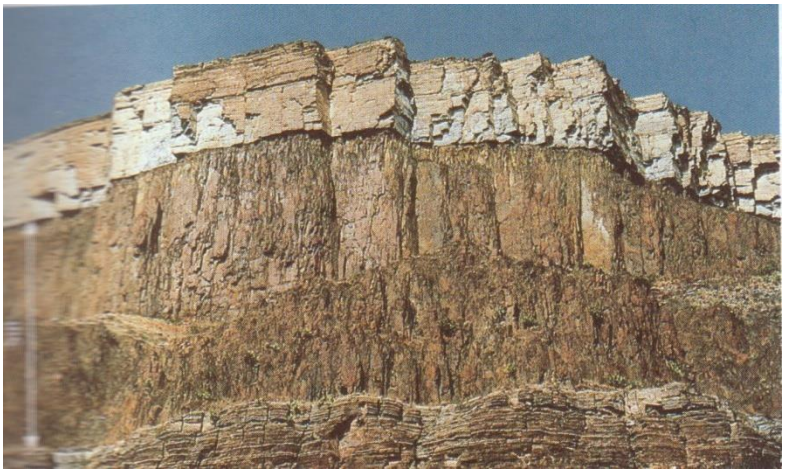
1. Dikes - they are tabular discordant masses that cut across foliation or bedding of the surrounding rocks. Usually they are emplaced into preexisting joint system, occurring singly or in swarms. Occassionally, vertical or outward dipping ring-dikes or inward dipping cone-sheets may be found in oval or circular patterns over an intrusion, being related to the doming action of the igneous body. The thickness, length and the composition of dikes vary in broad ranges.





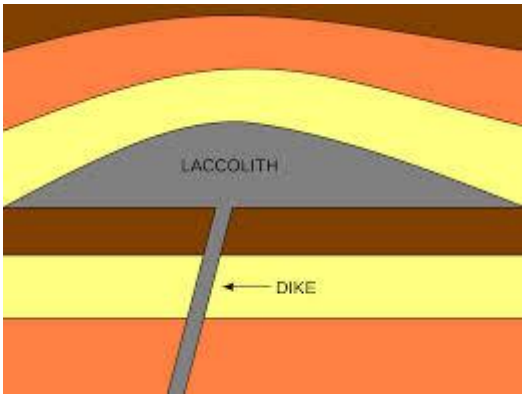


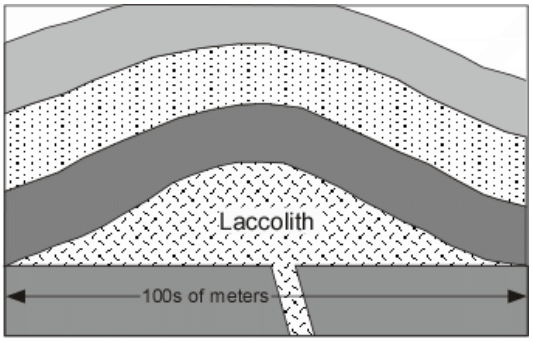
2. Sills - they are tabular bodies, emplaced essentially parallel to the foliation or bedding of the country rocks. They are usually of basic composition (basaltic), because such magmas are less viscous and can spread laterally. The thickness of sills may vary from a few to several hundred metres.



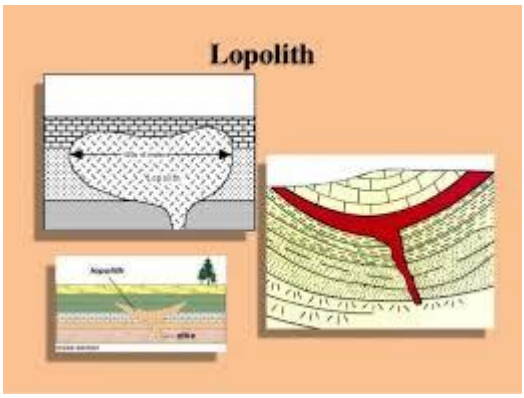
Ad B. The division is based mainly on the shape of intrustions:

1. Laccoliths - they are concordant, mushroom – shaped intrustions, formed when magma rising up spreads out laterally under more resistant layer. Most laccoliths are silicic or intermediate in composition and they may grade outwards into sill. Usually they are 1-8 km in diameter with thickness of 1/3 of their diameter.

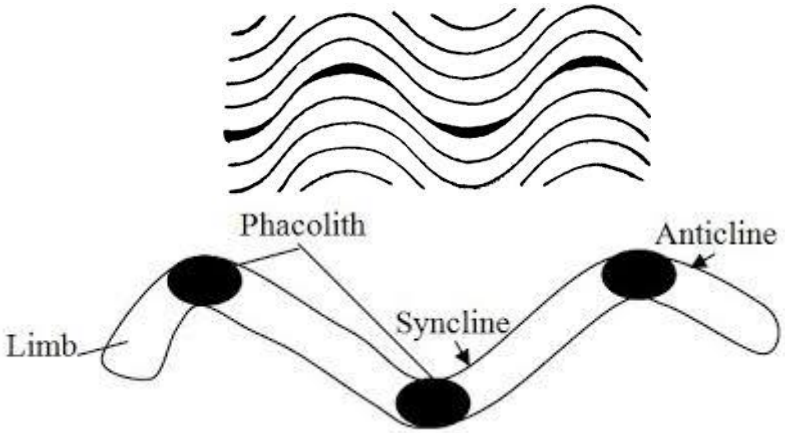




2. Lopoliths - they are lenticular, centrally sunken, generallyconcordant, basin – or funnel-shaped intrusive masses. The thickness is ** to ** of the width, and diameter ranges from tens to hundreds of kilometers. They are mafic to ultramafic in composition and a few have upper layers differentiated even to silicic derivates.

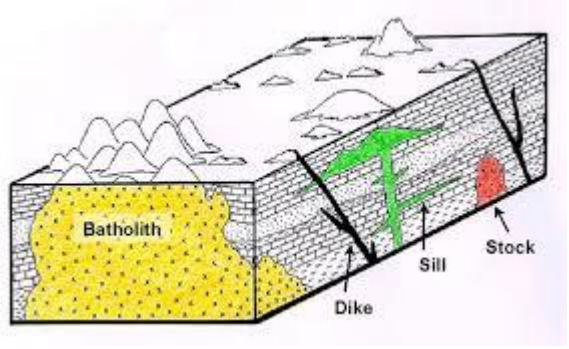


3. Phacoliths - lenticular concordant intrusions in the core of anticline or syncline (doubly convex upwards or downwards respectively). Emplaced after folding, with variable rock composition and extent up to tens of kilometers.



Ad C. Within this category fell only:

1. Batholiths - the large intrusive plutons with steeply dipping walls, typically without any known floor. They range in size to several thousand square kilometers and are usually silicic in composition. Smaller bodies, about 100 km^2, are called stocks and if they are circular in cross-section the name <u>boss</u> is used.



When the volcanic rocks are concerned, the type of their eruptions is governed by the viscosity of magma: the higher the silica content the higher viscosity. It means that basaltic magmas tend to erupt as fluid lavas with the formation of well-defined flows, whereas andesitic and especially rhyolitic magmas are so viscous that often erupt violently with formation of ejectamenta (ashes, blocks, bombs, etc). Those ejectamenta – pyroclastic rocks – will be discussed later as the group intermediate between the igneous and sedimentary rocks (igneous source of material with subsequent transport and deposition)

Under the subaerial conditions three main varieties of lavas can be distinguished:

1. block lava – composed of fragments relatively smooth, broken into pieces up to several meters in size and showing the signs of flow with tendency for some layers to shear over others,
   am

2. aa lava – with rough surfaces resembling the furnace clinkers. The clinker fragments are usually less than 15cm in diameter'

3. pahoehoe (ropy) lava – with rather smooth, glassy appearance, showing often the snaky folds.

Lava flows may vary from a few cm in thickness to about 200m and they cover the areas of hundred thousands of km^2. A complete gradation between different varieties of lavas may exist.

The submarine extrusions give:

1. pillow lava – it consists of ellipsoidal masses (10cm to 6m in size), piled one upon another, the intervening spaces being filled with the material of sedimentary origin. The structure of each pillow is composed of a glass crust and inside the composition is basaltic, andesitic or spilitic (altered sodic basalt).

The lavas, especially towards the top of the flow, display often the gas bubbles, trapped during the degassing of lava flow. They should

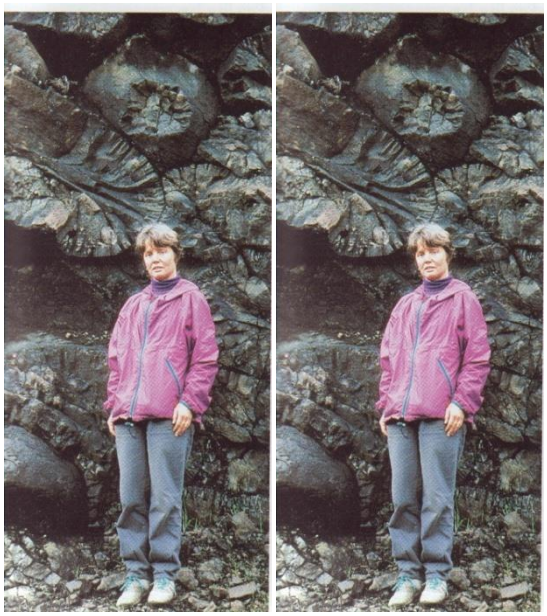


Figure 20 *A dome of viscous lava squeezed up from the dome*

Volcanic Landforms

Shield Volcanoes

- A shield volcano is characterized by gentle upper slopes (about 5^{o}) and somewhat steeper lower slopes (about 10^{o}).

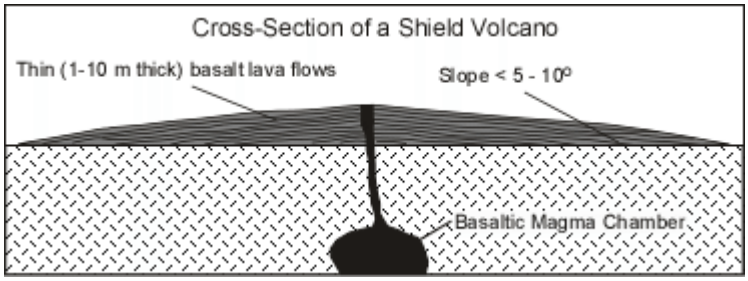


Figure 22 *Shield volcano*

- Shield volcanoes are composed almost entirely of thin lava flows built
- up over a central vent.
- Most shields are formed by low viscosity basaltic magma that flows easily down slope away form a summit vent.
- The low viscosity of the magma allows the lava to travel down slope on a gentle slope, but as it cools and its viscosity increases, its thickness builds up on the lower slopes giving a somewhat steeper lower slope.
- Most shield volcanoes have a roughly circular or oval shape in map view.
- Very little pyroclastic material is found within a shield volcano, except near the eruptive vents, where small amounts of pyroclastic material accumulate as a result of fire fountaining events**.**

Figure 23 *Shield volcano*

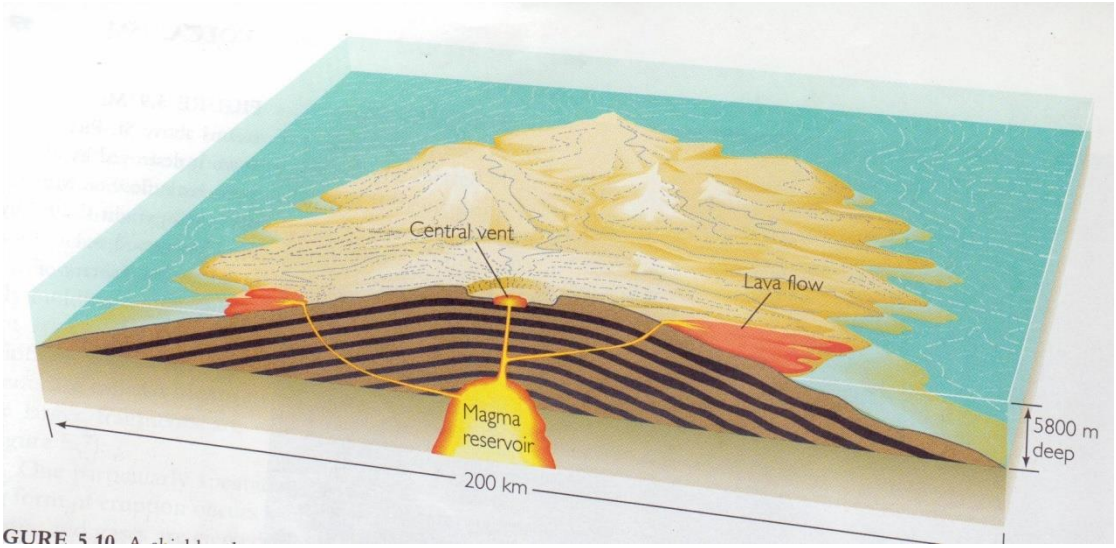


Figure 24 *A shield volcano is built up of thousands of thin basaltic lava flows that spread widely and cools as gentle sloping sheets*

Stratovolcanoes **(also called Composite Volcanoes)**

- Have steeper slopes than shields, with slopes of 6 - 10^{o} low on the flanks to 30^{o} near the summit.
- Steep slope near the summit result from thick, short viscous lava flows that don't travel far from the vent.

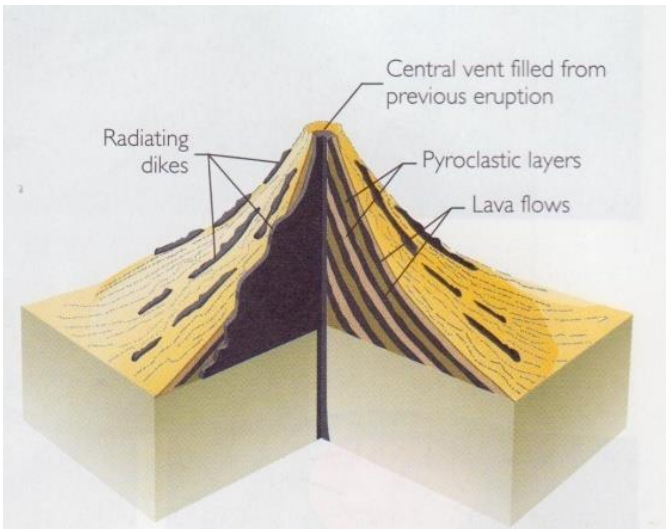


Figure 25 *A composite volcano*

volcano is built up of alternating layers of pyroclastic material and lava flows

Figure 26 *Fujiyama a composite volcano, Japan*

The gentler slopes near the base are due to accumulations of material eroded from the volcano and to the accumulation of pyroclastic material.

- Stratovolcanoes show inter-layering of lava flows and pyroclastic material, which is why they are sometimes called composite volcanoes. Pyroclastic material can make up over 50% of the volume of a stratovolcano.
- Lavas and pyroclastics are usually andesitic to rhyolitic in composition.
- Due to the higher viscosity of magmas erupted from these volcanoes, they are usually more explosive than shield volcanoes.
- Stratovolcanoes sometimes have a crater at the summit, that is formed by explosive ejection of material from a central vent. Sometimes the craters have been filled in by lava flows or lava domes, sometimes they are filled with glacial ice, and less commonly they are filled with water.
- Long periods of repose (times of inactivity) lasting for hundreds to thousands of years, make this type of volcano particularly dangerous, since many times they have shown no historic activity, and people are reluctant to heed warnings about possible eruptions**.**