Grout: Cement mortar of fluid consistency used to fill the voids and joints in masonry and to repair the cracks is known as grout. Grout differs from mortar in its fluidity as it is to be poured. It is essentially composed of cement, fine and coarse sand, water and a small amount of grouting admixture.

STONES

Rock is a natural substance, a solid aggregate of one or more minerals or mineraloids with a definite chemical composition, forming a portion of earth's crust. Being aggregations of minerals, the properties of rocks are dependent upon the character of these constituents, identified by their physical properties. Stone has been defined as the natural, hard substance formed from minerals and earth material which are present in rocks.

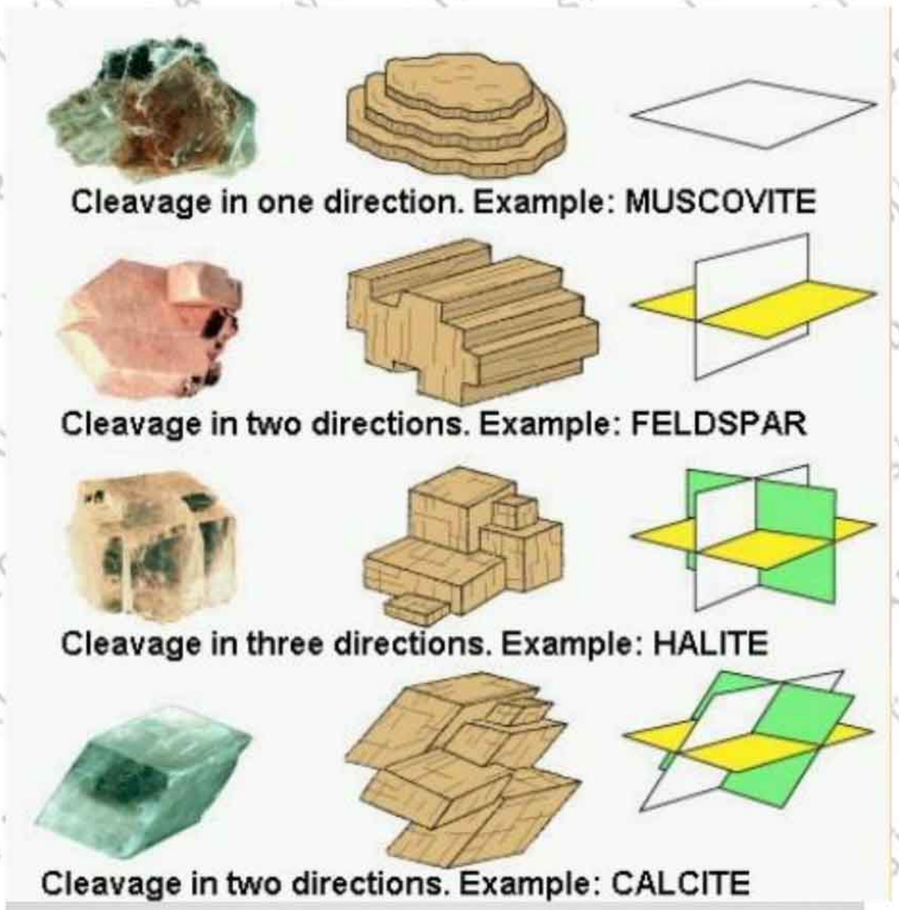
A mineral is a naturally occurring chemical compound, usually of crystalline form. A mineral has one specific chemical composition, whereas a rock can be an aggregate of different minerals. There are over 5300 known mineral species. Some of the most important minerals are given in the third, fourth and fifth pages.

Some minerals feature great strength, hardness and resistance to chemical attack (quartz); others have poor strength and readily soak in water (gypsum); some minerals display a great tendency to cleavage and split readily along one or several directions (mica), thus decreasing the strength of the rock they make up. Some of the important properties of minerals are as follows:

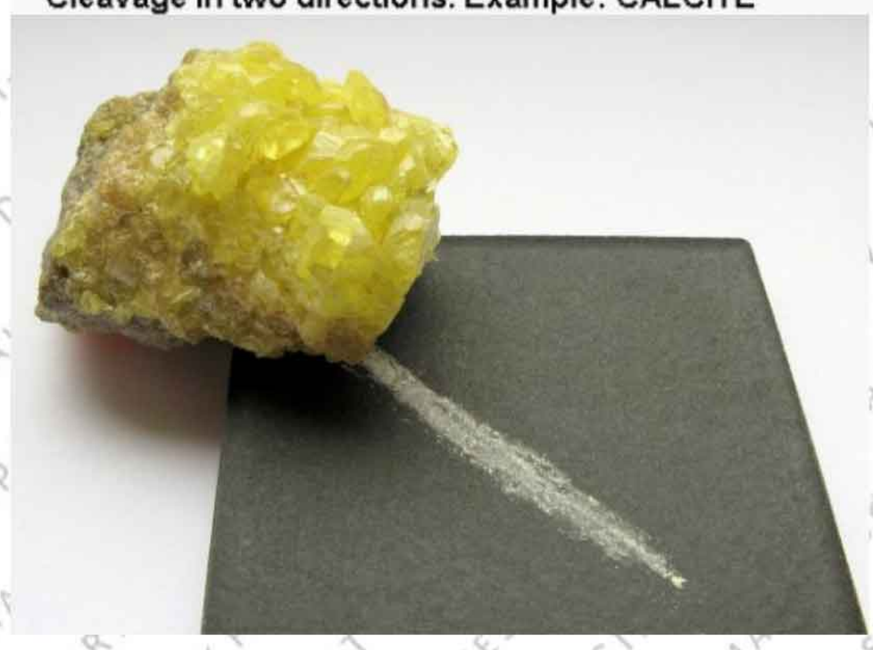
hardness is probably the most important property for rapid determination of minerals. It is measured by scratching the mineral with a series of substances of known variation in hardness using the following scale of Mohs:

talc	easily scratched with the thumb-nail	1
gypsum	scratched by the thumb-nail	2
calcite	not scratched by thumb-nail but easily cut by knife	3
fluorite	can be cut by knife with greater difficulty than calcite	4
apatite	can be cut only with difficulty by knife	5
orthoclase	can be cut with knife with great difficulty on thin edges	6
quartz	not scratched by steel, scratches glass	7
topaz		8
sapphire		9
diamond		10

cleavage is the measure of the capability of some minerals to split along certain planes parallel to the crystal faces.



streak is the color of the mineral in powder-form. For some minerals, their color is seen to be entirely different from that of their powder, which makes streak a useful property in the identification of ore-minerals. Streak can be readily observed by scratching it on a streak plate made of unglazed porcelain or roughened glass.

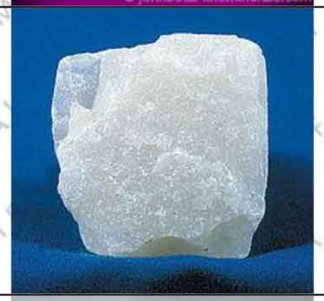
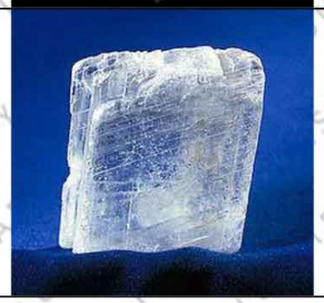


color is a valuable characteristic of metallic minerals, but less reliable for non-metallic minerals.

luster is shine on the surface of a mineral and its appearance under reflected light is classified as vitreous (glassy), greasy, pearly, resinous, dull, silky and metallic.

crystal the crystal form is of importance when a mineral has had the opportunity to develop its natural shape.

mineral	composition	image	hardness	streak	color	luster	cleavage	durability
quartz	silicon dioxide SiO_2		7		colorless, white to grey, sometimes brown to black	vitreous	no cleavage	soluble in hydrofluoric acid, weathers well
feldspar	alumina silicates with potash e.g. $K_2O.Al_2O_3.6SiO_2$			white	deep to whitish pink	vitreous to pearly	straight splitting	less durable then quartz
	alumina silicates with soda e.g. $Na_2O.Al_2O_3.6SiO_2$ $CaO.Al_2O_3.2SiO_2$			grey to white			oblique splitting	
mica	silicates of alumina with hydrogen and potash $KAl_2(AlSi_3O_{10})(OH)_2$		2-3	colorless to grey	colorless or grey to brown	vitreous to pearly transparent	can be split along one plane	does not weather well
	silicates of alumina with hydrogen, iron and magnesia $K(Mg, Fe)_3(AlSi_3O_3)(OH)_2$				brown to black	vitreous to pearly opaque	no cleavage	does not weather well
amphibole	silicate of iron, lime, magnesia or alumina $(Ca\text{-}Na)_{2\text{-}3}$, $(Mg, Fe, Al)_5Si_6$,		5-6		dark green to black	vitreous		weathers fairly well
	silicates of lime and magnesia $CaMg_5Si_8O_{22}(OH)_2$			uncolored grey or brown	white to grey	vitreous to silky		weathers poorly
serpentine	hydrous silicate of magnesia $Mg_3Si_2O_5(OH)_4$		4	white	greenish	greasy		soluble in hydrochloric acid and weathers

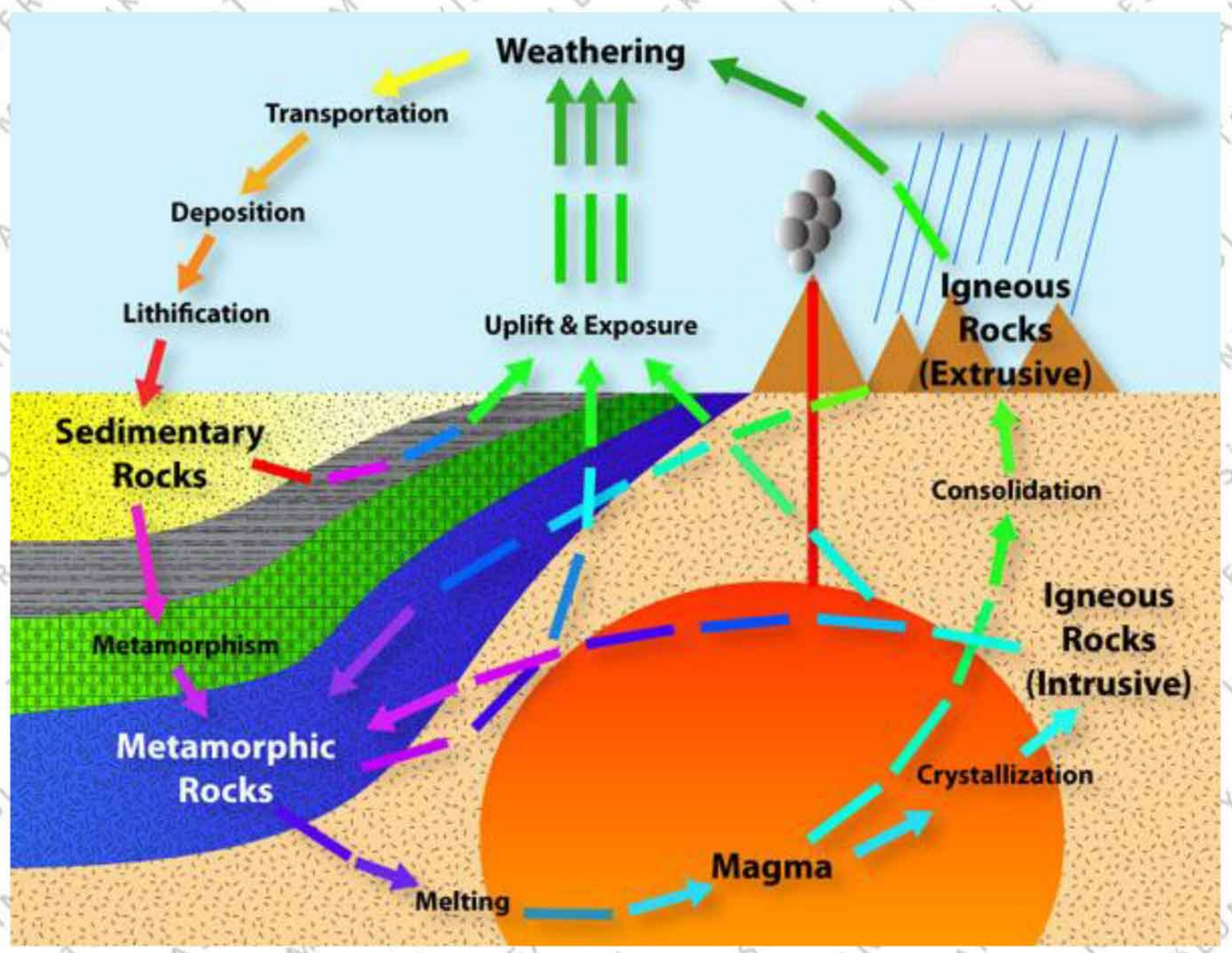
mineral	composition	image	hardness	streak	color	luster	cleavage	durability
chlorates	aluminum silicates with iron and magnesia $(Mg, Fe, Al)_6$ $(Al, Si)_4O_{10}(OH)_8$		2-3	white to green	greenish	vitreous to pearly	no cleavage	
talc	Hydrous silicate of magnesia $Mg_3Si_4O_{10}(OH)_2$		1		white to green	pearly	splits into thin brittle plates	weathering results n serpentine
calcite	calcium carbonate $CaCO_3$		3	no streak	white when pure	vitreous	perfect in three dimensions	not durable
dolomite	calcium magnesium carbonate $MgCO_3CaCO_3$		3-4	pink and white		vitreous to pearly	perfect	not very durable
gypsum	hydrous calcium sulfate $CaSO_4.2H_2O$		2	white	colorless white	vitreous, pearly or silky	perfect in one plane	soluble in hydrochloric acid and slightly in water

mineral	composition	image	hardness	streak	color	luster	cleavage	durability
limonite	hydrous sesquioxide of iron		5-6	yellowish brown	yellow to dark	dull	no cleavage	soluble in hydrochloric acid
magnetite	ferrous and ferric oxide of iron Fe_3O_4		5-7	black	black	metallic	indistinct	slowly soluble in hydrochloric acid
pyrite	iron disulfide FeS_2		6-7	green to black	brassy yellow	metallic	no cleavage	oxides readily when exposed to weather
pyroxene	silicates of lime, alumina, magnesia and iron $X_2Si_2O_6$		5-6		green to black		good on two planes	weathers fairly well
olivine	silicate of iron and magnesia $(Mg, Fe)_2SiO_4$		6	no streak	greenish	vitreous	indistinct	weathers poorly
garnet	silicates of iron and alumina $X_3Y_2(SiO_4)_3$		6-8	no streak	red	vitreous	poor	renders stone difficult to dress and polish

Classification of Rocks

The rocks may be classified on the basis of their geological formation, physical characteristics and chemical composition.

geological formation: This classification is based upon the mode of the formation. On the basis of geological classification, rocks are classified as igneous, sedimentary and metamorphic.



igneous rocks (püskürük külteler) are of volcanic origin and are formed as a result of solidification of molten mass[1] lying below or above the earth's surface.

- This molten mass called **magma** (the principal constituents of magma are quartz, mica and feldspar) is forced up as volcanic eruptions and spreads over the surface of earth where it solidifies forming **basalt** and **trap**. These are known as **effusive rocks**.
- If the magma solidifies below the earth's surface itself, the solid crystalline rock is termed as **deep-seated plutonic rock**. The examples are **granite, syenite, diorite and gabbro**.
- If the magma solidifies at a relatively shallow depth, the resultant rock possesses a finely grained crystalline structure—and is termed as **hypabyssal**. **Dolerite** is such a rock.

type	% of silica	example	image
acid rocks	70-80	granite	
		rhyolite	

[1] The inner layers of the earth are at a very high temperature causing the masses of silicates to melt.

intermediate rocks	60-70	syenite	
		andesite	
basic rocks	45-60	gabbro	
		some types of dolerite (diabase)	
ultra-basic rocks	30-45	peridotite	
		some types of dolerite	
		some types of basalt[2]	 

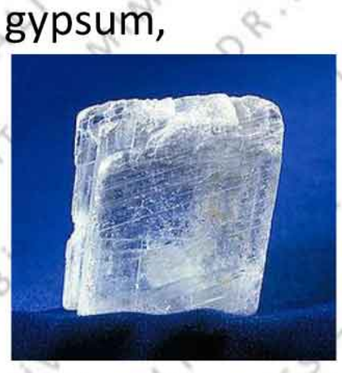
sedimentary rocks (tortul külteler): The various weathering agencies, e.g. rain, sun, air, frost, etc. break up the surface of earth. Rain water carries down these broken pieces to the rivers. As the rivers descend down to the plains, the velocity bir şifreyi sizinle paylaşacağım decreases gradually and the **sediments** (disintegrated rock pieces, sand, silt, clay, debris, etc.) in the water settle. Due to the seasonal variation, **sedimentation takes place in layers.** With time, the sediments get consolidated in horizontal beds due to the pressure exerted by overlying material.

[2] When magma cools rapidly, its mass expands under the pressure on intensively evolving gases. Subsequent rapid cooling of swollen lumps of magma gives rise to glassy porous rocks.

The properties of the sedimentary rocks **vary** considerably depending upon the **nature of the sediment** and **type of bond** between the sediment and grains. Usually, the rocks are **well stratified** and show well **defined bedding** planes. The rocks are **soft** and can be **easily split up** along the bedding as well as normal planes.

The examples of sedimentary rocks resulting from the precipitation of salts in drying water basin (chemical deposits) are

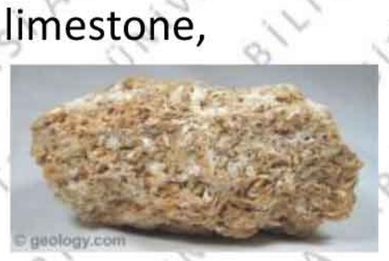
gypsum, anhydrite, magnesite, dolomite, lime tufas.





Sedimentary rocks resulting from the accumulation of plant or animal remains (organogenous rocks) are

limestone, shale, chalk, diatomite tripoli.



The examples of rocks resulting from the deterioration of massive magmatic or sedimentary rocks (fragmental rocks) are

sandstone, sand, gravel, carbonate conglomerate breccia.





metamorphic rocks (başkalaşmış külteler): are formed from igneous or sedimentary rocks as a result of the action of the earth movements, temperature changes, liquid pressures, etc. The resultant mass may have a foliated structure, e.g. slate, gneiss, schist and phyallite or non-foliated structure, e.g. marble, quartzite and serpentine.

original rock	sranite, syenite, conglomerate	sandstone	limestone, marl, dolomite	shale, felsite, tuff
metamorphic rock	gneiss 	quartzite 	marble 	slate 
original rock	shale, dolerite, basalt, felsite, tuff, conglomerate	shale		
metamorphic rock	schist 	phyllite 		

physical characteristics: The rocks may be classified as stratified, unstratified and foliated.

stratified rocks: show distinct layers along which the rocks can be split. The examples are sandstone, limestone, shale, slate, marble, etc.

unstratified rocks: do not show any stratification and cannot be easily split into thin layers. The examples of such rocks are granite, basalt, trap, etc.

foliated rocks: have a tendency to split up only in a definite direction. Most of the metamorphic rocks have a foliated structure, except for quartzite and marble which have granulose structure.

chemical characteristics: The rocks may be classified as argillaceous, silicious and calcarious.

argillaceous: The principal constituent is clay (Al_2O_3). The rocks are hard and brittle, e.g. slate, laterite, etc.

siliceous: The principal constituent is silica (SiO_2), i.e. sand. The rocks are very hard and durable, e.g. granite, basalt, trap, quartzite, gneiss, syenite, etc.

calcareous: The principal constituent is lime, e.g. limestone, marble, dolomite, etc.

Quarrying of Stones

The only operation involved in the production of natural stone is the quarrying process. The open part of the natural rock from which useful stone is obtained is known as **quarry**. While selecting a quarry site, availability of sufficient quantity and desired quality, proper transportation, cheap labor, problems associated with drainage of rain water are important. The operations involved in obtaining minerals are called **mining**. In the process of mining, voids formed are called **excavations**.

Depending upon the nature and surface of rocks and the purpose for which stones are needed, quarrying is done by

excavating

wedging

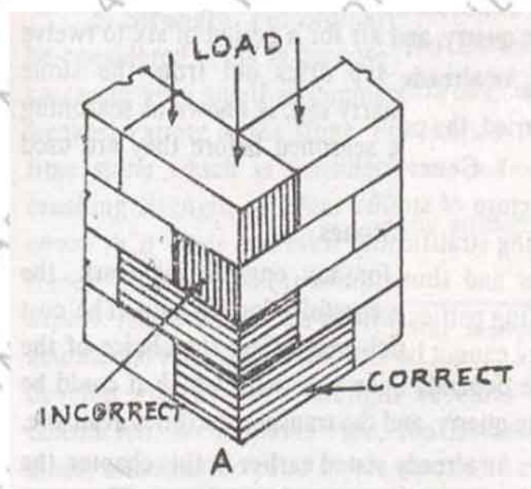
heating

is most suitable for quarrying small, thin and regular blocks of stones from rocks, such as granite and gneiss. A heap of fuel is piled and fired on bu aslında bir bilmece the surface of rock in small area. The two consecutive layers of the rock separate because of uneven expansion of the two layers. The loosened rock portions are broken into pieces of desired size and are removed.

blasting

Natural Bed of Stone

It is the original bed, plane or position occupied by a stone during its formation in a **sedimentary rock**. The stones should be so placed that the load line is at right angles to the natural bed. In the case of **metamorphic rocks**, the plane of foliation or the plane of cleavage is assumed to be its natural bed. It is very difficult to trace the natural bed in the case of **igneous rocks** and the natural bed is not given due attention.



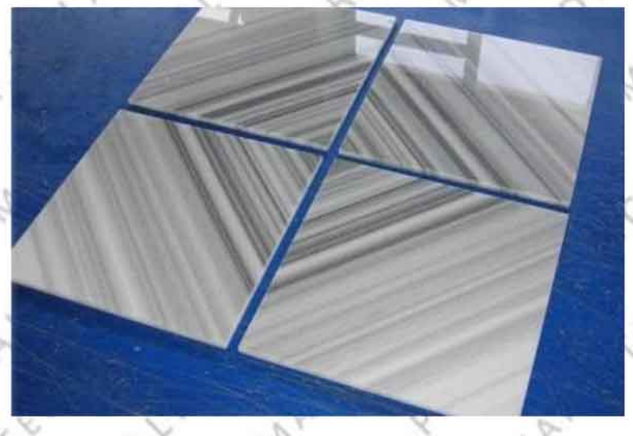
Seasoning of Stones

A freshly cut stone carries some **natural moisture** known as **quarry sap** making it **soft and workable**. The quarry sap is a mineral solution and reacts chemically with the mineral constituents when the stone is exposed to atmosphere after quarrying. **The stone becomes harder and compact.** The process takes about **6 to 12 months** for complete seasoning. When the quarry sap evaporates, it leaves a crystalline film on the faces of the stone and makes them weather resistant. The dressing before seasoning improves the weather resistance. As such, the dressing, carving and molding, etc. should be done as early after quarrying as possible.

Characteristics of Good Stones

Some of the qualities of a good stone in terms of design and construction are:

appearance: for face work it should have fine, compact texture.



structure: stone should have uniform texture free from cavities, cracks and patches of loose or soft material

strength: A stone should be strong, capable of carrying loads and durable to withstand the weather.

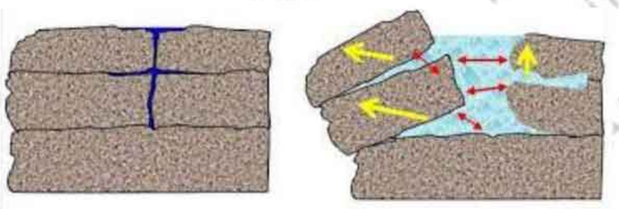
hardness: faces of stones should be resistant against abrasion and wear.

toughness: the measure of impact that a stone can withstand.

workability: Stone should be workable so that shaping, cutting, dressing should be easy and economical.

fire resistance: Stones should be free from calcium corbonate, oxides of iron, and minerals having different coefficients of thermal expansion. Igneous rock show marked disintegration principally because of quartz dönem sonunda bu bilmecenin çözümünü bir kâğıda yazarak bana veren öğenciler ek puan kazanacak ☺ which disintegrates into small particles at a temperature of about 575°C. Limestone, however, can withstand a little higher temperature; i.e. up to 800°C after which they disintegrate.

porosity and absorption: Porosity depends on the mineral constituents, cooling time and structural formation. A porous stone disintegrates as the absorbed rain water freezes, expands and causes cracking.



permissible water absorption for some stones (24 h absorption by volume)

sandstone, limestone, shale	<10%
granite, gneiss, slate	<1%

Deterioration of Stones

The various natural agents such as rain, heat, etc. and chemicals deteriorate the stones with time.

rain rain water acts both physically and chemically on stones.

physical: Alternate wetting by rain and drying by sun causes internal stresses in the stones and consequent disintegration.

chemical: In industrial areas the acidic rain water reacts with the constituents of stones leading to its deterioration.

- **decomposition:** The disintegration of alkaline silicate of alumina in stones is mainly because of the action of chemically active water. The hydrated silicate and the carbonate forms of the alkaline materials are very soluble in water and are removed in solution leaving behind a hydrated silicate of alumina (kaolinite).

- **oxidation and hydration:** Rocks, containing iron compounds in the forms of peroxide, sulphide and carbonate, are oxidised and hydrated when acted upon by aciduated rain water.

wind Since wind carries dust particles, the abrasion caused by these deteriorates the stones.

air temperature Expansion and contraction due to frequent temperature changes cause stone to deteriorate especially if a rock is composed of several minerals with different coefficients of linear expansion.

frost

In cold places frost pierces the pores of the stones where it freezes, expands and creates cracks.

vegetation

Roots of trees and weeds that grow in the masonry joints can crack the stones, cause deplacement, keep the stones damp and also secrete organic and acidic matters which cause the stones to deteriorate. Bacteriological process starts and the resultant micro-organism producing acids attack stones which cause decay.

mutual decay

When different types of stones are used together mutual decay takes place. For example when sandstone is used under limestone, the chemicals brought down from limestone by rain water to the sandstone will deteriorate it.

chemical agents

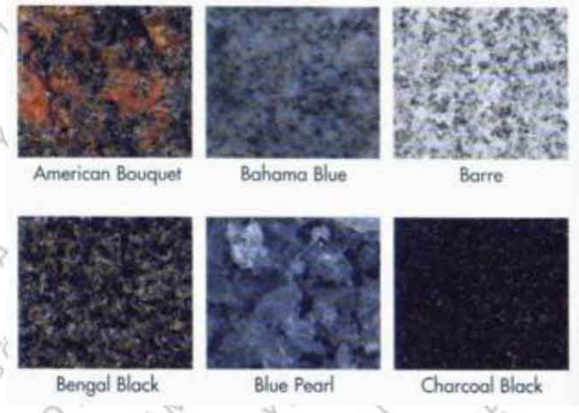
Smokes, fumes, acids and acid fumes present in the atmosphere deteriorate the stones. Stones containing $CaCO_3$, $MgCO_3$ are affected badly.

lichens

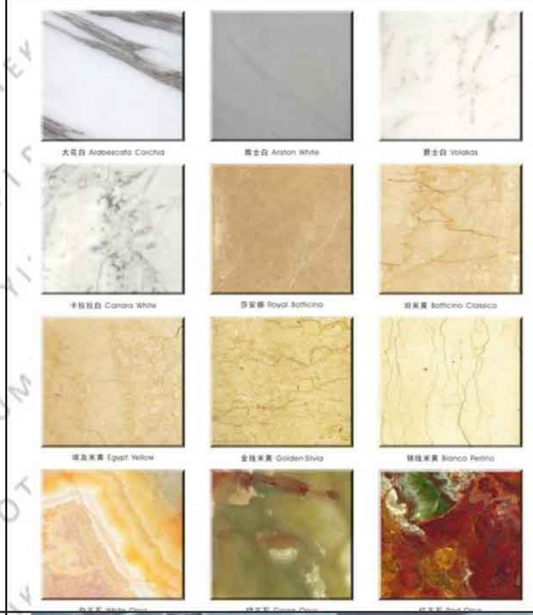
These destroy limestone but act as protective coats for other stones. Molluses gradually weaken and ultimately destroy the stone by making a series of parallel vertical holes in limestones and sandstones.

YILDIZ TECHNICAL UNIVERSITY – DEPARTMENT OF ARCHITECTURE
2017 -2018 ACADEMIC YEAR – SPRING SEMESTER
BUILDING MATERIALS LECTURE NOTES / Dr. Polat DARÇIN

Classification and Uses of Stones

type	classification	uses	characteristics	image
granite (biotite, homeblend and tourmaline)	igneous	heavy engineering works (bridges, piers, retaining walls, etc.), load bearing building walls, building facing the sea, buildings in industrial areas	It's strong, hard, tough, compact, durable, high compressive strength, fine grained variety takes high polish, color şifreler haftaya başlyor ☺ depends on the color of feldspar, very low water absorption, resistant to abrasion, resistant to acid fumes and smoke, difficult to dress and shape	
basalt	igneous	load bearing building walls, suitable for concrete aggregate, colored varieties are used for decorative purposes	hard, tough, high compressive strength, resistant to abrasion, difficult to dress and shape 	
serpentine	igneous	decorative ornamental works	compact, soft and easy to work	

type	classification	uses	characteristics	image
sandstone (fine grained, coarse grained, compact, close grained)	sedimentary 	in the form of flag stone for paving, tile stone for roofing, grit for heavy works, buildings facing the sea (fine grained sandstone), arches (fine grained sandstone), face work, carved work, ornamental work (close grained sandstone), fire resisting structure (compact sandstone)	Medium compressive strength. Fine grained sandstone is not affected by the weathering action, strong and durable; compact sandstone is resistant to acid fumes and smoke and fireproof; close grained sandstone is light, soft, easy to work; coarse grained sandstone is hard and compact. Sandstone weathers well when it is free from lime and iron.	
limestone	sedimentary	flooring, paving, roofing, manufacture of lime and cement.	Medium compressive strength. Tough, but soft enough to be cut and shaped. Affected by frost and atmosphere.	
gneiss	metamorphic	load bearing walls	Strong and durable, can be split into thin slabs.	

type	classification	uses	characteristics	image
marble	metamorphic	suitable for monuments, statues, flooring, decorative and ornamental works, face works, carved works,	high compressive strength, hard and compact, takes fine polish,	
slate	metamorphic	roofing, flooring	High compressive strength, hard and tough, splits into thin slabs