Some Common Rocks and Minerals

The sixth in Nature Magazine's series of special educational inserts

By E. LAURENCE PALMER

No one would assume that an eight-page article could deal exhaustively with birds, insects or trees. It is hoped that no one would expect this article on rocks and minerals to be anything like a complete treatment of the subject. If it leads one to consult more exhaustive sources, or to make first-hand studies of the rocks and minerals available locally, it will have served.

While it is doubtful that anyone without some previous experience could, with the help of the material given here, identify accurately or appreciate thoroughly any great number of rocks, some activities may be suggested that will help one to learn directly about the properties of local rocks and minerals.

This page may merely help define some of the words used in the charts that follow. Almost anyone can distinguish the substances that are called mud, sand, gravel, humus, snow and lime. But what happens to these things if they are left to themselves? We know that they may be washed here and there by water; that they may be blown by the wind; that they help or interfere with the cultivation of lands. Mixing them, we can make the surface of the earth suitable for highways, for growing roses, or for pasturing cattle. Almost all that is done in agriculture involves such activities, and agriculture affects all peoples.

Consider also what happens to these things when buried under great masses of earth, exposed to high or low temperatures, subjected to twisting strains, or changed slowly or quickly in any way. Briefly, most of them may be compacted to points where, if a mass is lifted, adjacent parts will be lifted also. The individual grains with which we started may still be recognized, even though they may have been cemented together in one way or another. Such consolidated materials may be formed from sediments dropped in moving currents of air or water, thus making *sedimentary rocks.* This may loosely be compared to what happens when snow falls to form snowbanks.

If the consolidated materials are pressed further they may change their nature, and form *metamorphic* rocks. The chemical nature of these rocks may be the same as when they were sediments but they differ physically.

These metamorphic rocks may be buried still deeper or changed further by heat, or by other means, until they may become a molten mass. The rocks thus formed are *igneous.* If this mass is allowed to cool slowly, or the pressure is released slowly by the mass above wearing away through erosion or other means, the materials in the molten mass may variously crystalize. Rocks formed in this way are *intrusive,* while those that relatively more quickly make their way to the surface through cracks or are released through volcanic action are *extrusive.* Rocks of each of these types are discussed in the succeeding charts. These igneous rocks—and the others as well—when exposed to the action of weather break down irregularly. The softer parts naturally wear away first. Those parts that are easily dissolved in water will disappear more quickly than others, and sooner or later both soft and hard parts may be piled up again as sand or mud or gravel.

So far as the minerals are concerned each of these may be investigated by anyone to his own satisfaction. Some of the things to look for are suggested in the keys to the charts on minerals. Others might easily have been added. But all of the characteristics used in describing rocks are determined by what happens when they are struck, broken, bent, twisted, squeezed, frozen, illuminated by different kinds of light, heated, exposed to water or acids or to an electric current; how they behave when mixed with other minerals under varying conditions and with which they will mix; how much they weigh, and so on. Mineralogists have naturally established standards for measuring the qualities of the different minerals. For example *hardness* is compared with that of a diamond, which has a hardness of 10, and talc, which has a hardness of 1. The other minerals range between these figures. Similarly a scale of *fusibility* has been established to denote at what temperature the substance will melt. Instead of using degrees on a thermometer it is more common to say that a substance like sulphur, which melts at a point a little above that of boiling water, has a fusibility of 1, while quartz, which, even in the hottest part of a flame of a blowpipe, will not melt, has a fusibility of 7, or is ordinarily considered infusible. Homely ways for carrying on some simple experiments in this field are given on the School Page of this number.

This article is a modification of a similar one by the author published as one issue of the *Cornell Rural School Leaflet* by the New York State College of Agriculture at Cornell University. It is felt that reactions to material in that number of the *Leaflet* have permitted improvement in this presentation. Appreciation is expressed to the College for permission to revise this material and to use it to supplement the author's personal experiences with rocks and minerals. The illustrations are by the author and his wife, Dr. Katherine Van Winkle Palmer. Recommended are:

Elements of Mineralogy, Crystallography and Blowpipe Analysis, by Alfred J. Moses and Charles Lathrop Parsons, D. Van Nostrand, New York. 1906.

Dana's Manual of Mineralogy, by William E. Ford, John Wiley and Sons, New York. 1912.

Fieldbook of Common Rocks and Minerals, by Frederic Brewster Loomis, G. P. Putnam's Sons, New York. 1923.

Handbook of Chemistry and Physics, by Charles D. Hodgmen and Norbert A. Lange, Chemical Rubber Publishing Company, Cleveland, Ohio. 1928.

Getting Acquainted with Minerals, by George Letchworth English, Mineralogical Publishing Company, Rochester, New York.

Quartz Family Minerals, by H. C. Dake, Frank L. Fleener and Ben Hur Wilson, McGraw-Hill Company, New York. 1938.

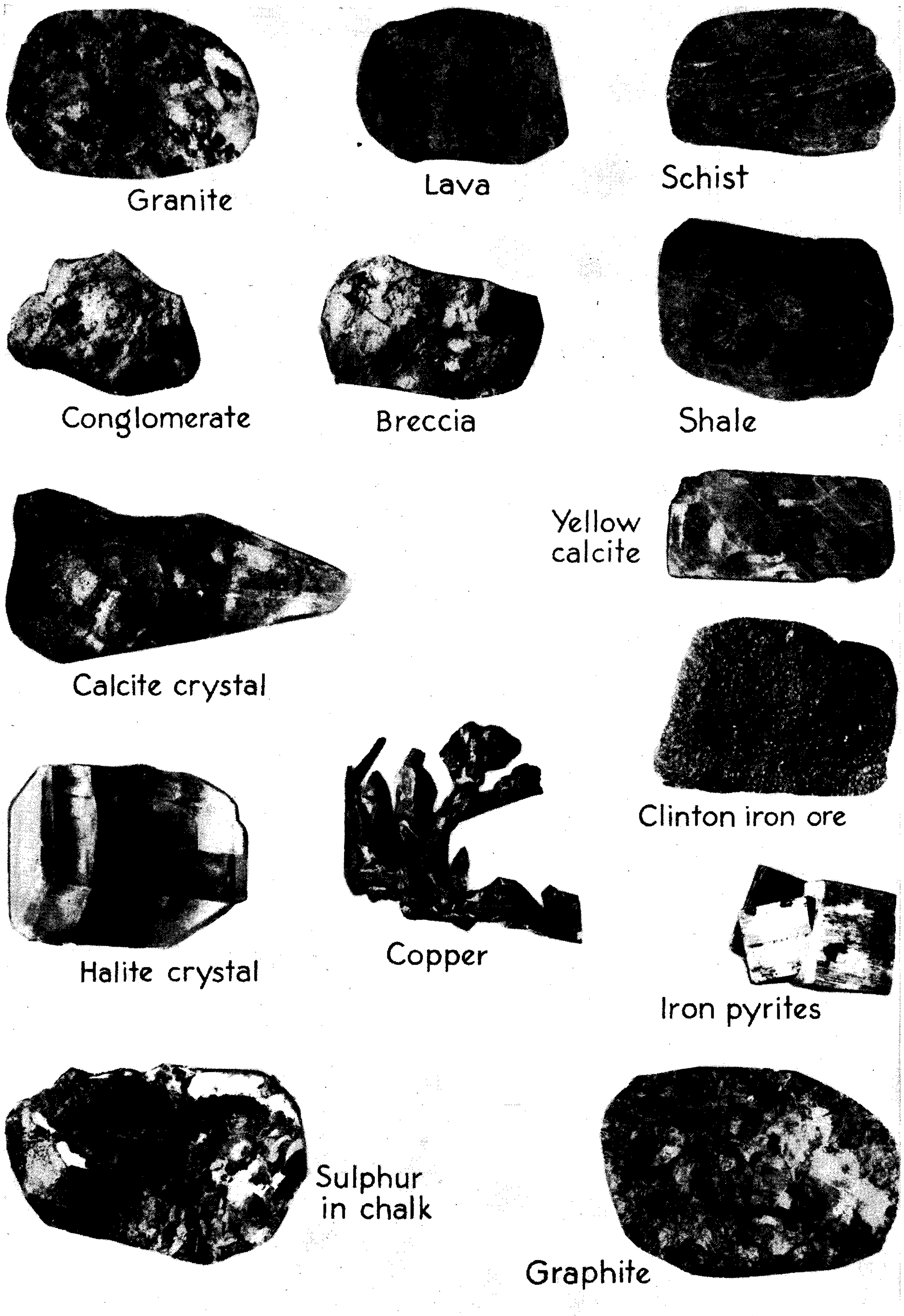
Granite
Lava
Schist
Conglomerate
Breccia
Shale
Yellow calcite
Calcite crystal
Clinton iron ore
Halite crystal
Copper
Iron pyrites
Sulphur in chalk
Graphite

PLATE 1.

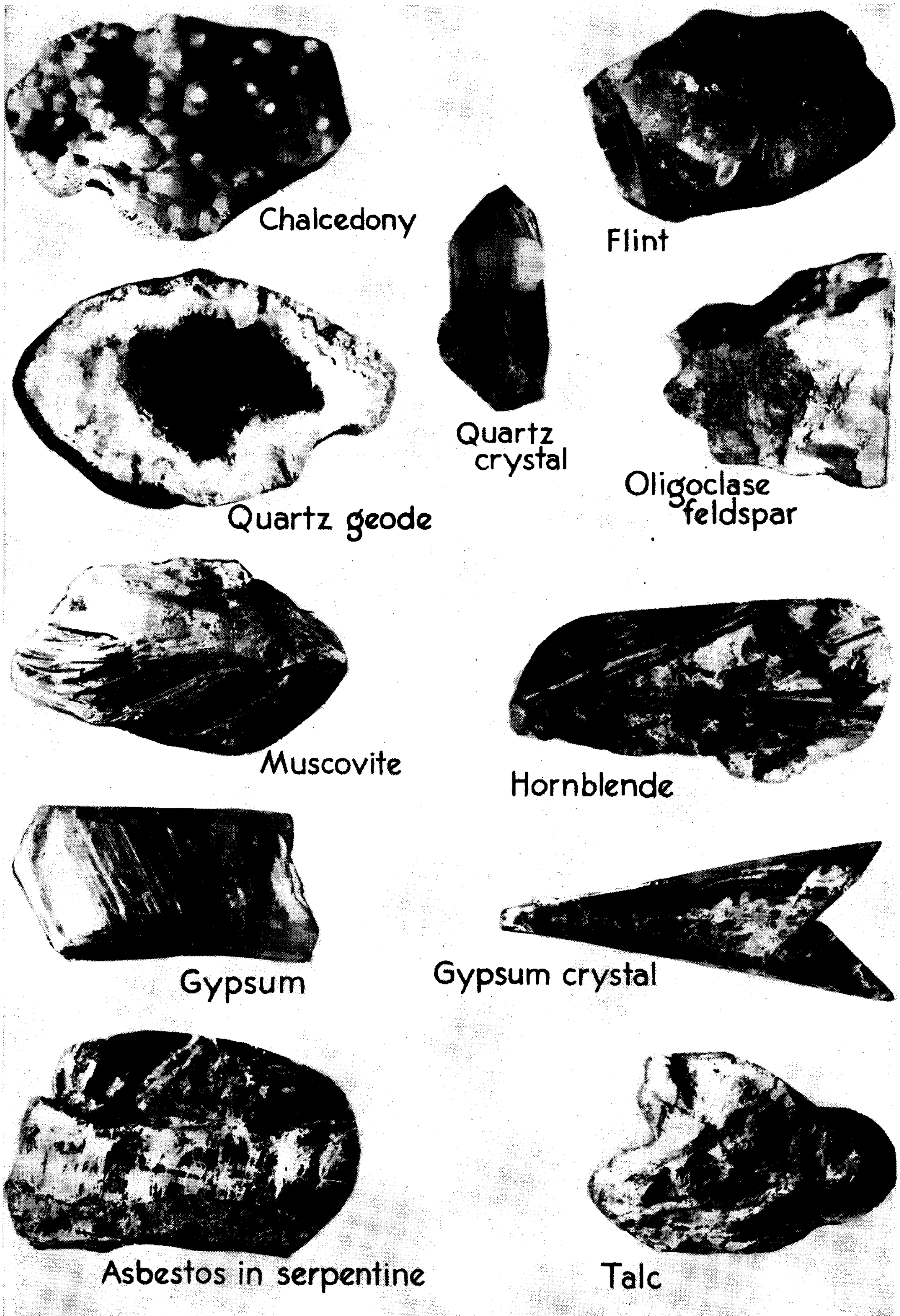
Chalcedony
Flint
Quartz crystal
Quartz geode
Oligoclase feldspar
Muscovite
Hornblende
Gypsum
Gypsum crystal
Asbestos in serpentine
Talc

PLATE 2.

UNCONSOLIDATED MATERIAL **Nature**	GRAVELS and TALUS. Composed of pieces of rock larger than peas. If water-worn and with rounded edges, it is gravel, but if made of angular pieces unworn, as at foot of cliffs, it is talus.	SAND. Much sand is quartz made from the disintegration of such quartz-bearing rocks as granite. Coral-beach sands may be of lime. Ordinarily of particles smaller than peas.	MUD. Loose, generally fine-grained earthy materials commonly formed of softer parts of rocks such as kaolin, feldspars, micas, and so on. When dry, loose dust or compacted clays. Insoluble.	LIME CARBONATE. Animals and plants in the sea convert soluble lime carbonate — $H_2Ca(CO_3)_2$ —into the insoluble— $CaCO_3$—freeing carbon dioxide. Algae and foraminifera vital in this.
Where found and how formed	Commonly formed in watercourses where there is a swift current, or at base of tall cliffs and mountains. Gravels may be formed by wave action, which rolls and wears the materials.	Materials that are deposited from moving air or water before the silts, muds and clays. May make extensive dunes and deserts and border many waterways, as the Great Lakes.	In slowly-moving parts of waterways, over the depths of the oceans and as *loess* by wind over great stretches of land. May form loose floor on bottom of waterways dangerous or helpful to life.	Foraminifera may be the size of a grain of sand or much larger. Lime deposits may cover the sea floor or form marl in bodies of fresh water. Corals associated with some lime deposits.
Uses	Common as fillers in road-building. Used in concrete, and, since it does not hold water well, may be used for playgrounds, paths and the like. Suitable for limited kinds of plants.	Quartz sand may be biologically nearly sterile, but may hold valuable mixtures and provide superior waterholding qualities for some plants in some regions. Unstable, needs anchorage.	Properly mixed with air, chemicals and water, mud provides excellent growing medium for plants. Helps build up richest fertile areas on the earth and supplies major sources of farm wealth.	Chalk is slightly consolidated lime. Great beds of rock are built by lime-depositing creatures. Agassiz estimated coral could build up about 40 feet of deposit in 1000 years.
CONSOLIDATED SEDIMENTS **Nature**	CONGLOMERATES are consolidated gravels cemented together and showing water-worn character of component units. BRECCIA is made of consolidated rocks not water-worn.	SANDSTONE is chiefly quartz sand cemented with silica, iron oxide or clay, but, when broken, shows sand grains. May be porous so that 30 percent is space between the grains. May hold water.	SHALES are consolidated muds still in the layers in which they were laid down and frequently splitting along planes of varying degree of fineness of composing materials. Generally weather away.	LIMESTONES are compacted lime carbonate. They effervesce when treated with hydrochloric acid except that dolomitic limestone of calcium carbonate and magnesium does only with hot acid.
Where found and how formed	Conglomerates in which the cements and pebbles or bowlders are contrasted are called pudding-stones. Many conglomerates show by scratches their origin in glacial action.	Constitutes about 15 percent of the stratified rocks of the earth. Varies in strength due to differences in cement. ARKOSE is sandstone made of unaltered feldspar; origin, continental or marine.	Constitute about 80 percent of the stratified rocks that overlie the bed rocks of the earth. Some are of fine, hard quality, in uniform beds; others, loosely consolidated and of a heterogeneous nature.	Limestones constitute about 5 percent of the earth's stratified rocks. The lime may be mixed with sand, clay and other materials. Lime deposits are commoner in warmer seas.
Uses	May be cut and used as building stones, which are attractive if component parts vary greatly. Useful in interpreting the physical geography of the past where they are found.	Quarried or crushed and used in the building trades, although less so than in the past. Probably less used than limestone. May be crushed and used in road building.	Some are used in the making of cement; others, make flagstones. They both help and interfere with maintaining a water supply since their irregular nature affects the water table.	Valuable as source of lime for fertilizer and making mortar. Heated to just over 900°C, is so changed that, if water is added, the mixture may become as hard as the original limestone.
METAMORPHIC FORMS **Nature**	GNEISS (pronounced nice), formed of quartz, feldspar and mica, with mica usually in more or less definite plane giving a banded appearance in cross section. Little pore space.	QUARTZITE is metamorphosed sandstone so firmly cemented that fracture may take place through component sand grains rather than around them. Of quartz sand with silica cement.	SLATES are shales metamorphosed by pressure and heat into flat plates, which may not agree with the original stratification. The mineral grains are too fine to be seen with a lens.	MARBLE is metamorphic limestone changed by heat to a crystalline rock. Uniformly textured, does not tend to split. Marble takes a high polish; limestone does not.
Where found and how formed	There is a tendency for gneiss to split in one direction. The rocks are conglomerates changed by heat and tremendous pressure. Hornblende may replace the mica. Garnets may occur.	Found as rock or as very hard pebbles. If mashed in formation, may appear as a *quartz schist*, or, if impure because of presence of mud, a MICA SCHIST may be formed.	Found in older rocks such as the Cambrian and Ordovician, an important supply coming from Vermont, New York, Virginia and elsewhere. Rocks are quarried, split and sawed or ground.	Large quarries in Vermont, Massachusetts, Pennsylvania, and in many places in the West. In dolomitic marbles, calcium carbonate is largely replaced by magnesium carbonate.
Uses	Heavy hard rocks originating deeply. May be broken and used in heavy construction activities. SCHISTS are usually softer and weather less successfully.	Quartzites and schists may be too hard to be cut conveniently, but crushed quartzite is used in concrete work, in road building and in glass making.	Formerly used principally in natural planes as tables, roofing, flooring; now used also with asphalt filler and paint in making artificial tiling, shingles and the like.	Used in interior decoration and in monuments. Used in the latter way may deteriorate by weathering but will serve for a reasonable period.

ORGANIC MATERIAL, the remains of plants and animals, either their bodies or waste products, make loose *humus* in the soil and provide acids, salts and carbon compounds.	WATER. H_2O. Freezes at 0°C or 32°F; boils at 100°C or 212°F. Tasteless. Tansparent. Almost universal solvent, so rarely pure in nature. As vapor forms clouds, fogs; collects as dew and rain.	**INTRUSIVE ROCKS Light-colored** **Nature**	GRANITES, a combination of quartz, orthoclase feldspar and hornblende or augite; often with mica. Usually light in color. Usually individual minerals visible to naked eye.	SYENITE, with texture like granite; of orthoclase and either hornblende, augite or mica but always without quartz. It may include other feldspars than orthoclase. Light-colored.
These materials help in breaking down of rock compounds and themselves add to the chemical nature of the mixture. They may accumulate as in peat beds and bogs, or be dissipated.	In all living things. Covers 139,440,000 square miles of the earth's 196,950,000 square miles of surface, and rare only over the 5,000,000 square miles of desert; otherwise in soil.	**How Formed**	Igneous; cooled very slowly, probably under great pressure. Intrusive. Large grains set in collection of smaller grains form *granite porphyry.* Varieties named from dark minerals.	Formed like granite and cooled slowly under pressure, commonly under the folds of mountains. Less common than granite and does not occur in such large masses. Intrusive.
Valuable as source of food for plants of many sorts, as fuel when dried, as mulches in gardens, as holders of soil moisture. Green manures renew the supply, which may be exhausted.	Essential to life in solution of foods, translocation of foods and wastes. Important in mingling parts of earth's surface and important aid to commerce for man. Provides beauty and recreation.	**Use and Where found**	Common in Adirondacks, Lake Superior region, Black Hills, Rocky Mountains and Sierra Nevadas. Superior building stones. Basic for much soil formation.	Best localities in Arkansas, Colorado, the White Mountains, eastern Canada from Labrador to Ontario, Minnesota, Norway and elsewhere. Used as building stones.
Consolidated organic remains may be in many forms as PEAT, BITUMINOUS COAL, or, if from bones, shells and waste products, may be GUANO, ROCK PHOSPHATES and the like.	SNOW BANKS. Formed by crystallization of water vapor into 6-pointed stars and settling by gravity through the atmosphere to form strata of snow in banks or great layers. White. Slippery.	**INTRUSIVE ROCKS Dark-colored** **Nature**	DIORITE without quartz but with plagioclase feldspar plus mica and/or hornblende. GABBRO with plagioclase feldspar and any phroxene, commonly augite.	PERIDOTITE, blue or dark rocks composed of olivine and any of the pyroxenes; generally appear to be made of large crystals. No feldspar. May include garnet, chromite and others.
Phosphate beds occur in Tennessee, the Carolinas, Florida, great area in western South America in Chile. Soft coal deposits extensive through the Great Basin and elsewhere.	Covers the polar caps of the earth and extends toward the equator in winter seasons and at great elevations. Can form protective blanket preventing rapid changes in temperature.	**How Formed**	Igneous; cooled slowly much like granite. Intrusive. May appear as a porphyry, or of the even granular type. Dense gabbro with small crystals is DIABASE-formed near surface.	Generally associated with and formed like gabbro, differing in the absence of feldspar. Usually found as dykes, sheets and small intrusions. Are intrusive. They are not common.
Essential use is as fertilizers, fuel and in certain types of manufacturing industries. Some highly valuable in making explosives, useful in agriculture and unfortunately in war.	Helps many winter plants and animals by insulating cloak. Provides continuous flow of water from high altitudes. Assists in some types of transportation. Provides beauty and recreation.	**Use and where found**	Associated with the other igneous rocks but particularly good in the White Mountains and in the Rockies. Used extensively as building stones. Both generally dark.	Important sources of platinum, chromium, nickel and diamonds. Generally dark and heavy because of iron in them. Diamonds of Africa and Arkansas from these rocks.
Metamorphosed carbons may appear as GRAPHITE, as DIAMONDS and as ANTHRACITE COAL. Of these, the diamond is the hardest and the graphite the softest.	ICE. Formed by freezing of liquid water. Increases in volume when freezing. May be caused by increased pressure within limits as in parts of glaciers. When pure is transparent. Brittle.	**EXTRUSIVE ROCKS** **Nature**	BASALT or traprock, a mixture of plagioclase feldspar, magnetic iron ore, olivine and a pyroxene. Crystals not seen. Dark. FELSITE, light and with more feldspar.	OBSIDIAN, clean, lustrous, hard glass which forms crusts on lava flows. If duller, the substance is PITCHSTONE; if frothy, PUMICE. Always hard; often has gas cavities. Extrusive.
Diamonds usually associated with volcanic origin. Hard coal is formed by softer coals under pressure. Natural gas and petroleum also of organic origin.	Covers bodies of fresh water in colder parts of the earth. When expanding in freezing, breaks up many rocks and in glacier form grinds rocks. May cause death of plants and animals.	**How Formed**	Formed by molten materials being forced up into other rocks through cracks and fissures large or small.	Formed by the quick cooling of lava flows from volcanoes. Material which is expelled explosively may form volcanic ash, tuff and volcanic breccia.
Uses well-known and varied. So valuable that individuals as well as whole nations do not hesitate to try to annihilate others who possess these forms of wealth.	Serves as reservoir for water. May kill fish by cutting off access to air and water birds by cutting off access to food. Provides unique transportation, sport, and helps preserve foods.	**Use and where found**	One of commonest igneous rocks in New England, the Palisades of the Hudson, in Lake Superior region and the far west particularly northwest. Used for filling and ballast.	Found in Rockies, California, the Cascades, Sierra Nevadas, the Yellowstone. Primitive peoples used it for knives, ornaments and weapons. Pumice used for polishing.

NAME OF MINERAL	CALCITE (Lime) $CaCO_3$	HALITE (Salt) NaCl	GALENA (Lead Ore) PbS	SULPHUR S
COLOR, STREAK AND WEIGHT	White to colorless, or sometimes tinted with pink, yellow or blue, with a glassy or earthy luster. Streak, colorless. Effervesces freely with hydrochloric acid. Weight, 2.72 times that of water. Clear crystal of Iceland spar shows double refraction of light.	Colorless to white, translucent or transparent, vitreous, soluble in water and producing a colorless streak. Weight, from 2.1 to 2.2 times that of water. It, of course, tastes salty.	Lead-gray color, metallic, producing a lead-gray streak. Crystals, opaque, are inclined to glisten and sparkle because of their exposed faces. The metal is not easily penetrated by radium. Galena is 7.5 times as heavy as is water. Poor conductor of electricity.	Characteristic sulphur-yellow or even gray to brown or reddish. Masses, opaque, but crystals sometimes translucent. Resinous for most part. Streaks, pale yellow or white. 2.05 to 2.09 times as heavy as water. Good insulator of electricity. When rubbed, becomes negatively charged. Non-metallic native element.
HARDNESS, FRACTURE AND CRYSTALLIZATION	Hardness, 3, may be scratched with a penny. Conchoidal fracture seldom seen because of ease of cleavage which is perfect in three directions oblique to each other and at about 105°. Structure, granular, earthy, stalactitic or crystalline. Crystallization, hexagonal, rhombohedral, prismatic; may twin and be of great beauty.	Hardness, 2.5, may be scratched with a fingernail. Cleavage, perfect cubes. Crystals, nearly always cubes but sometimes hopper-shaped or with faces concaved by four-sided pyramids. Halite is often granular, massive to compact, depending upon method of crystallization.	Hardness, 2.5, and can be scratched by a cent. It breaks in three directions parallel to the cube faces showing isometric cubes or crystals. Highly malleable, ductile. The ore is cleavable, coarse or fine grained, massive. When fine grained, it may seem to be compact. Occasionally octahedral crystals are formed.	Hardness, 1.5 to 2.5, may be scratched with the fingernail. Very brittle though masses may sometimes be cut. Some forms plastic. Has an uneven or conchoidal fracture and no distinct cleavage. Occurs in orthorhombic crystals often in double pyramids or is earthy, stalactitic, fibrous, reniform, massive.
GENERAL RECOGNITION CHARACTER AND HEAT EFFECTS	Occurs as veins; in caves, as stalactites; as deposits in springs, in shells of animals; as cementing material in sandstones; cementing shells together to make coquina; as limestone; chalk or marble asssociated with igneous, sedimentary or metamorphic rocks.	Solubility in water and the taste usually suffice for quick identification. 100 grams of water at 100° C. will dissolve 39.8 grams of salt.	Melts in a candle flame as globules of metallic lead on galena. Melts at 327° C; boils at 1525° C. The outstanding characters are the weight, softness and usual cubic cleavage which may make it seem to be brittle.	Melts at just above boiling point of water, or from 112.8° to 119.3° C. Very poor conductor of heat and will crackle when warmed due to differences in rate of expansion.
WHERE AND IN WHAT FORMATIONS FOUND	Most limestones are accumulated animal shell remains or deposits of lime from water. These layers are built up, forming great beds which may be raised to mountain ranges. Subjected to pressure and heat they may turn to marble. Loosely compacted, they may make true chalk (not school chalk which is gypsum).	Makes up about 2.5 percent of seawater, more in some lakes, and found as rock salt where ancient seas have dried up. Germany, Austria, New York, Michigan are leading producers of salt. It is associated with gypsum and in the Southern and Western states the presence of salt is used as an index to the possible presence of petroleum.	Found in veins and irregular masses in igneous and in metamorphic and commonly in masses in sedimentary rocks. Associated with sphalerite, chalcopyrite, pyrite, calcite and argenite. Possibly most widely distributed of metallic sulphides. Important mines in Missouri, Utah, Colorado, Idaho, Iowa, Kansas and Oklahoma. 1937, U. S. production about ½ that of 1924 but thrice that of 1931.	Found in beds commonly associated with live or extinct volcanoes, in gypsum beds or salt beds, also combined with metals as sulphides such as galena, pyrite and chalcopyrite, and as sulphates when united with metallic oxides as in gypsum, barite and others. Sulphur is widely distributed in the world but Texas and Louisiana beds are the most successful commercially.
USE AND COMMERCIAL ABUNDANCE	One of the most important minerals to life, building bones and shells. Fresh-water sponges are not found in limy waters but snails and other molluscs are. Portland cement is made of lime, shale and gypsum, and in 1937 was 171 million dollar United States industry. Lime alone was a 30 million dollar industry. Its value in limestone and as fertilizer and in other products is not easily obtainable.	Essential to the life of most animals. Used in cooking and preserving food, in manufacture of glass, soda ash and soap, in bleaching and in industry, also used in refrigeration, to some extent in the care of roads, in oil refining, and as the chief source of sodium compounds used by the chemical industries. United States produces about ⅓ of the world's salt, annually about 8 million tons.	Extracted by roasting the ore, frequently as a by-product in the extraction of silver, with which it is commonly associated. United States production in 1937 about twice that of second-place Australia. Used in making pipes, paints, bullets, poison compounds, in solder and type-metal, for linings for tanks, and in electrical equipment, as in dry cells, and in many other ways.	Extracted by forcing steam into beds, melting the sulphur which is forced out and then cools and hardens. United States leads in production followed by Italy and Japan. Texas beds average 125 feet thick. Used in chemicals as insecticides, in medicine and fertilizers, in vulcanizing rubber, in gunpowder, matches and in making sulphuric acid for industrial uses.

COPPER and COPPER ORE (Chalcopyrite) Cu and Cu FeS_4	IRON ORES (1) Pyrites FeS_2 (2) Hematite Fe_2O_3 (3) Magnetite Fe_3O_4 (4) Limonite $Fe_4O_3(OH)_6$	QUARTZ SiO_2	MICAS (1) Muscovite $H_2K\,Al_3(SiO_4)_3$ (2) Biotite $(HK)_2Al_2(SiO_4)_3$	KAOLINITE China Clay $H_4Al_2Si_2O_9$
Copper, red to black and tarnishes; ore, brassy yellow. Both metallic. Copper streaks shining copper red; ore streaks black. Copper, 8.9 times as heavy as water; ore, 4.2 to 4.3 or about 5 times as light as gold. Copper, 2nd to silver as a conductor of electricity.	Color, (1) brass yellow; (2) red-brown to black; (3) black; (4) dark brown to black. Luster, metallic, in (1) splendent; in (4) dull. Streak, (1) green to brown black; (2) Indian red; (3) black; (4) yellow brown. Weight, (1) 4.95 to 5; (2) 4.8 to 5.3; (3) 5.18; (4) 3.6 to 4 that of water. Metal very ductile, malleable.	White, yellow, pink, blue, smoky, black, green, red, brown or transparent with a glassy, splendent to dull luster. May appear to be greasy. Crystalline and massive varieties. Insoluble. Streak, white, colorless. Weight, 2.6 to 2.7 times that of water.	(1) Yellow to white, pearly, vitreous. Weight, 2.76 to 3. (2) Brown to black, splendent. Weight, 2.95 to 3.2 that of water. Both are elastic, and if thin sheets are hit with a dull instrument 6-rayed star "percussion figures" are formed. Some, transparent.	White to grayish blue or yellowish, dull. Insoluble and about 2.6 times as heavy as water. Heat resistant. Opaque. Streak, colorless.
Hardness, copper, 2.5; ore, 3.5 can be scratched with a knife. Copper, highly ductile and malleable; the ore, brittle. Copper, rough or jagged fracture; ore, uneven. Copper occurs in irregular grains, sheets, isometric cubes or octahedral crystals; ore, in metallic veins, tetragonal or sphenoidal crystals.	Hardness, (1) 6 to 6.5; (2) 5.5 to 6.5; (3) 6; (4) 5 to 5.5. Fracture, uneven in (1) and (3), uneven or fibrous in (2) splintery in (4). Crystallization, (1) isometric cubes with striated faces or granular; (2) earthy, mica-like or in hexagonal rhombohedral crystals; (3) granular or massive, isometric, octarhombohedral crystals; (4) earthy, fibrous or otherwise, noncrystalline.	Hardness, 7, not scratched with glass. Fracture, conchoidal to uneven. Brittle. Cleavage, rare. Crystals, hexagonal and other types. Crystalline varieties: colorless; smoky amethyst; milky quartz. Massive varieties: waxy, translucent chalcedony; variegated chalcedony or agate; banded or onyx agate; opaque or semitranslucent, tough, usually gray flint; splintery chert; opaque, colored jasper.	Hardness, (1) 2.25; (2) 2.5 to 3 both easily scratched with fingernail. Both split into sheets as thin as 1/500 of an inch. Crystals are rare, monoclinic in six-sided plates sometimes some feet across. The lithia mica *lepidolite* lacks distinct cleavage but occurs in small scales. Phlogopite may show star when light is transmitted. It is usually amber.	Hardness, 2, may be scratched with fingernail. In compact, claylike masses or friable. By weathering or changing of feldspar, the potassium of feldspar unites with carbon dioxide to make water-soluble potassium carbonate. The water, part of the silica and aluminium make kaolinite. Generally not in crystals.
Excellent conductor of heat. Melts at 1083°C; boils at 2310°C. Almost all of the copper minerals are brightly colored. This and hardness help in identification. Chalcopyrite is softer than steel and might be confused with gold but for weight.	(1) Easily fusible to magnetic globule; (4) fusible with difficulty; (2) and (3) infusible. (1) Soluble in hydrochloric acid; (2) and (3) slowly soluble. Good conductor of heat and of electricity. (3) Strongly magnetic. Metal melts at 1530°C.; boils at 2450°C.	Fusible with great difficulty. The massive quartzes do not break to show the crystalline form, some like pseudomorphus quartz replace organic material as in petrified wood, others may have been formed by cooling quickly.	(1) Thin splinters melt with blow pipe; (2) melts with difficulty. Lepidolite may be melted on a coal stove. The softness, sheet cleavage, luster and elasticity are sufficient for ordinary identification.	Identified by friable nature, the fact that when dry it sticks to a wet tongue and gives off a characteristic clay odor when breathed upon. Is always dull but when burned may change in appearance and become very hard.
Found pure or in other ores, best combinations being in chalcopyrite, chalcocite, bornite and tetrahedrite. Unlike gold, the chalcopyrite sometimes called fool's gold is brittle when pounded and produces black streak. Found in igneous and sedimentary rocks particularly in Lake Superior region, also in Alaska, Arizona, California, Michigan, Montana, Nevada, New Mexico, Tennessee and Utah.	(1) Found extensively with chalcopyrite, sphalerite and galena in veins in igneous and in sedimentary rocks; (2) in oolites, columnar crystals in igneous rocks, red sandstones and with metamorphic rocks particularly in Minnesota, Alabama and Michigan; (3) in sands, beds, plates and lenses in Scandinavia and New York; (4) in beds, marshes, caves, on surface in Alabama particularly.	About 12 percent of earth's crust to depth of 10 miles. Found in veins, in granites, sandstones, sand, conglomerates, gneisses, schists, quartzites, rhyolites and pegmatite. Some of best crystals found in limestone in New York; others, in Arkansas. Amethyst gems of quartz from Brazil and the Ural Mountains, chalcedony from western states and Germany, and jasper from Siberia and Africa.	(1) Best from India, North Dakota, Virginia and North Carolina as commercial isinglass. (2) Best from Vesuvius and Canada. Lepidolite found with pink tourmaline in California and in Maine in coarse grains. Phlogopite, best from Canada where it is found in limestones and in serpentine. Micas may be in veins or disseminated through rocks.	Associated with feldspar-bearing rocks. Contributes to the muds coming from disintegrating granites, the quartz parts of the granite remaining as sand. Rather generally and widely distributed through the world.
Copper and tin, early used by bronze age man. Extracted by smelting, leaching or electrolysis. Used now in electric wiring, copper plating, roofing, piping, marine equipment, nails and money. A 1-cent piece is about 95 percent copper, 4 percent tin and 1 percent lead. Copper produced in United States in 1937 was worth $202,000,000, more than twice that of second-place Chile.	(1) in manufacture of sulphuric acid and as index in Africa of gold. (2), (3) and (4) as source of iron and (4) as yellow ochre in paints. U. S. production of iron and steel in 1937 about 88 million gross tons; twice that of Germany; nearly 3 times, Russia, 4 times, Great Britain, 8 times, France and 10 times, Japan and Belgium.	Used in crystalline form for gems, ornaments, optical and chemical apparatus, as sandpaper, in glass and cement; in massive forms as plaster, in soaps, pottery, paints, and as building stones. Sand and associated gravels in the United States in 1937 was worth approximately 100 million dollars. Quartz forms the rigid backbone of such valuable building stones as granite, sandstone and quartzites.	(1) Used as sheets in stoves and electrical equipment or ground to use in wall paper, as artificial snow for theatres or Christmas decorations, in paints, roofing and tires. (2) No commercial use. Lepidolite may be used in glass but phlogopite is the best of the micas for electrical uses. American micas are useful only in the inferior ways for the most part.	Used in making tiles, drain-pipes, bricks, stoneware, roofing, crockery, fire bricks, paper filler, and the finer forms in the making of porcelain and of china.

NAME OF MINERAL	FELDSPARS (1) Orthoclase $KAl\ Si_3O_8$ (2) Plagioclase $Na\ Al\ Si_3O_8$ (3) Albite to $CaAl_2Si_2O_8$ (Anorthite)	AMPHIBOLES (1) Tremolite $CaMg_3(SiO_3)_4$ (2) Actinolite $Ca(Mg\ Fe)_3(SiO_3)_4$ (3) Hornblende $CaMg_3(SiO_3)_4$ and $Na_2Al_2(SiO_4)_3$ and $Mg_2Al_4(SiO_6)_2$	SELENITE (Gypsum) $CaSO_4 2(H_2O)$	SERPENTINE TALC SOAPSTONE (1) $H_4Mg_3Si_2O_9$ and (2) TALC or $H_2Mg_3(SiO_3)_4$
COLOR, STREAK AND WEIGHT	(1) White, colorless, gray, flesh-red, vitreous. Streak, white or colorless. Weight, 2.5 to 2.6 that of water. Insoluble in acids. (2) Varied opalescent, vitreous to pearly. Weight, 2.62 to 2.75. All are silicates of aluminum and one or more other metals.	(1) White to light green. (2) Green. (3) Dark green to black. Luster, vitreous. Streak, colorless. Weight, 3 to 3.3 times that of water. *Asbestos* is a fibrous variety and *nephrite* is a tough, compact "green stone."	Colorless to white, gray, yellow or brown, vitreous to pearly, soluble in hot hydrochloric acid. Weight, 2.32 times as heavy as water. Streak, colorless. Selenite, transparent crystal. Alabaster, white, fine grained, translucent. Rock gypsum, coarse.	(1) Olive to blackish green, yellowish green to white or translucent when thin, with a greasy, waxy or silky luster. Streak, colorless. Weight, 2.5 to 2.65 times that of water. (2) Green to gray, pearly to greasy. Weight, 2.8 times that of water.
HARDNESS, FRACTURE AND CRYSTALIZATION	Hardness, (1) 6 to 6.5; (2) 6, softer than quartz. Cleavage, (1) splits in 2 directions, 90° angle; (2) basal perfect, oblique. Structure, (1) crystalline, cleavable, to granular; (2) massive; cleavable, crystals rare. Crystallization, (1) Monoclinic, (2) triclinic. Fracture, uneven; in glassy crystals of (1), it may be conchoidal.	Hardness, 5 to 6, may be scratched with glass. Cleavage, perfect, prismatic at 125°. The minerals are opaque, semitranslucent or sometimes transparent. Crystallization, monoclinic, prismatic. Tremolite breaks into splinters which pierce the skin. Actinolite commonly occurs as plates or blades in schists. Hornblende is in short crystals in some volcanic rocks.	Hardness, 2, may be scratched with the fingernail. Unusual tenacity being both flexible and able to be sliced. Some varieties are fibrous. Fracture is in 3 directions, leaving rhombic plates. In selenite, the largest face looks pearly, while the other two show conchoidal fracture in one and fibrous in the other. Crystallization, monoclinic.	Hardness, (1) 3 to 5, usually 4; (2) 1, may be scratched with fingernail. Poor conductors of heat and not attacked by acids. (1) may have tough, fibrous or flexible varieties and subconchoidal or splintery fracture. (2) Has basal cleavage and may occur in fibrous or other forms, flexible but not elastic. Crystallization, monoclinic but true crystals of (1) unknown.
GENERAL RECOGNITION CHARACTER AND HEAT EFFECTS	Fusible with difficulty. Simplest difference is oblique cleavage in (2) and right-angle cleavage in (1). Prominent cleavage of (1) shows no striations; of (2) almost always shows striations.	Fusible easily with blowpipe. Hornblende the commonest, appears usually as opaque black parts of basalts, schists and granites. It has a definite cleavage, thus differing from black tourmaline, which it otherwise may resemble.	May form crystals over 5 feet long or appear as massive, fibrous, granular or earthly material and may be identified by its hardness, its luster and its solubility in hot hydrochloric acid.	(1) Infusible. (2) Fused with difficulty but some kinds become very hard when heated excessively and are used as tips on gas burners. Color and general softness, the greasy feel to (2), and the general luster, are good identification characters.
WHERE AND IN WHAT FORMATIONS FOUND	Orthoclase, a potassium feldspar, is found as sanidine in common eruptive rocks like trachyte and rhyolite. Another potassium feldspar, microcline, occurs in large masses in pegmatite and similar rocks. Plagioclase includes the usually white soda-feldspar, albite, the dark gray labradorite and the usually lighter-colored sodium and calcium feldspar oligoclase.	Associates are suggested above. In schists, hornblende is usually fibrous or in blades; in volcanic rocks, in short thick prisms. Nephrite, the "jade" of New Zealand is compact but asbestos is fibrous. This is not the commercial asbestos which is made mostly from serpentine. Amphiboles are usually distributed through rocks but not always so.	Found generally in beds sometimes of great thickness commonly in sedimentary rocks associated with salt, calcite, sulphur, pyrite, dolomite and quartz. Best beds of selenite in Utah, Texas, Mexico and France; of alabaster, in Italy; of satin spar in Siberia, England and Nevada. Rock gypsum more generally distributed.	(1) Serpentine marble of the tougher forms quarried in England, Italy, Ireland, France, Greece, New England, along the Hudson near New York, and at Philadelphia and Baltimore. Chrysotile, a fibrous variety, makes asbestos. (2) Talc as soapstone is quarried in Virginia and North Carolina; the fibrous talc in New York and foliated talc in Rhode Island.
USE AND COMMERCIAL ABUNDANCE	Feldspar constitutes about 60 percent of the earth's crust to a depth of 10 miles. Feldspars, with mica, form the softer aprts of granites. They are used in making porcelain, as a source of aluminum. Some are of gem quality; some in glass industry and in pottery. Found in granites, gneisses and sandstones. Some are used in building stones.	Used associated with the rocks of which they are a part. While asbestos may have 18 inch fibers it is not commercially used. Some forms have semiprecious jewel qualities and are used in making various ornaments.	Most important use of gypsum in making plaster of paris, also a part of cement and of general building plaster and land plaster. Alabaster is used in making statuary and carvings of various sorts; and satin spar, in making of ornaments. School "chalk" is made of gypsum.	Serpentine is used as building stones and the fibrous variety chrysotile is spun into yarn to make fireproof fabrics, heating pipe covers, fireproof shingles, stove linings and the like. Talc in its tougher forms is used as soapstones for washtubs, switchboards, tables, toilets and tanks. In its fibrous form it is used as filler for paper and paints and, in foliated form, in cheap toilet powders.