gneisses; and for these reasons, and also because they are regarded by many geologists as belonging wholly to the class of eruptive rocks, the illustration is comparatively limited. The composition of the different varieties is expressed with sufficient fullness on the labels. The two specimens of syenite from Marblehead (**1, 4**) are quite typical; but it occurs there under conditions which make its sedimentary origin doubtful. Neither of the diorite specimens are well characterized; the first (**2**) being too highly hornblendic and the second (**3**) too compact and slaty. The norite specimens on the second shelf are all from the west shore of Lake Champlain and are fine illustrations of the principal varieties of this rock. Some (**21**) are nearly pure Labrador feldspar, while others show the supposed stratification (**24**) very plainly and also an interesting accessory mineral — garnet (**22**).

Mica Schist. — This is by far the most important, as well as the most typical, of all the schists; and, next to gneiss, it is the most abundant rock in New England. The illustration begins, as before, with the composition. First, the essential constituents — quartz and black and white mica (**42**); and, second, a few only of the numerous and interesting accessory minerals (**44**). The first two specimens of mica schist (**41, 43**) may be regarded as very typical examples, exhibiting the schistose texture to good advantage. One of them (**43**) shows in addition garnet, the most important crystalline accessory of mica schist.

The remaining specimens on this shelf (**45-49**) are examples of highly siliceous or quartzose schists, contain-

ing only enough mica to develop the schistose texture. They indicate a gradual passage which is often observed from mica schist to quartzite. The specimens on the next shelf include the beautiful schist with green mica, from Maine (**61**); and, besides additional examples of garnetiferous mica schist, varieties depending upon other accessory minerals, such as tourmaline (**67**), fibrolite (**68–69**), and ottrelite (**70**).

The illustration of the varieties of mica schist is continued on the third shelf of the next section (17). We find here a good specimen of staurolitic schist, containing distinct cruciform twins of staurolite (**49**). The crystals are, however, often much less conspicuous (**50**). Very similar to the staurolitic schists, and scarcely less abundant, are those containing andalusite (**45**) and especially the impure variety of andalusite known as chiastolite (**46–47**).

The chiastolite is readily recognized by the appearance of a black square or cross on the sections of the crystals (see p. 103); and both the staurolitic and chiastolitic mica schists are usually highly argillaceous and of a distinctly slaty structure. Some of the plain argillaceous schists (**41**), especially, show very clearly how we may have a perfect transition from mica schist into common slate. These mica schists in which kaolin takes the place of quartz are always imperfectly crystalline and slaty, and sometimes calcareous (**42**) or carbonaceous (**48**). Pyrite is one of the less important accessory minerals (**51**). The important variety hydromica schist, in which hydromica takes the place of ordinary mica, is well illustrated by the specimens (**62-64, 66–68**) on the fourth shelf of this section (17). These are distinguished by being softer, greener, and less distinctly crystalline; and they are also often, like the true mica schists, argillaceous (**68**), and contain other hydrous silicates, such as chlorite and pinite (**64**), and they may also be calcareous (**66**). Garnet and other anhydrous accessory minerals occur much less frequently than in true mica schist.

Hornblende Schist. — This rock is like mica schist with hornblende in the place of mica. It is a less typical schist, and also much less abundant, than mica schist. The composition is most clearly illustrated by the coarsely crystalline specimen from Chester (**45**) (3d shelf, section 18), bladed crystals of hornblende as well as the finely granular white quartz being clearly exhibited. The finely crystalline kind (**41**) is, however, much more normal and abundant. The specimen from Rowe (**46**) is a particularly good illustration of the stratification. The garnetiferous specimen (**42**) may be regarded as the exception that proves the rule that hornblende schist is less characterized by accessory minerals than mica schist.

Amphibolite or Hornblende Rock.—This rock is essentially pure hornblende, or like hornblende schist without the quartz, or diorite without the feldspar, and gradations are observed between it and both of these species. The specimens from Chester (**43–44**) illustrate the typical variety as well as the gradations.

Schorl Schist, Garnet Rock, etc.—The rarer kinds among the anhydrous schists are represented by the specimens on the next shelf (4th shelf, section 18). These are: (1) *Schorl schist* or *tourmaline schist*, consisting of black tourmaline imbedded in granular quartz. The specimen from Warwick (**61**) is well characterized.

(2) *Topaz schist*, consisting essentially of topaz and quartz (**65**). (3) *Garnet rock* (**62, 66**), in which common garnet is the chief and sometimes the sole constituent. (4) *Epidote rock* (**63, 67**), consisting chiefly of massive epidote with more or less quartz, etc. (5) *Graphite schist* (**64**), composed of quartz and graphite, resembling a mica schist in which scaly graphite takes the place of mica. This rock is of economic interest, being an important source of commercial graphite. (6) *Eklogite*, a rock of exceptional and variable composition and of doubtful sedimentary origin (**68, 70**).

The remaining schists, occupying the bottom shelf of sections 16, 17 and 18, include as essential constituents only minerals belonging to the hydrous silicates, such as talc, pyrophyllite, pinite, glauconite, serpentine, and chlorite and we might properly add hydromica to the list.

Talc Schist or Steatite —This interesting rock is essentially pure talc, though often containing quartz, chlorite, hydromica, etc. as accessories. It is often distinctly schistose or foliated (**81–82, 85**), although usually massive, as in common soapstone (**89–90**). The foliated forms are generally the purest and may be pulverized for lubricating purposes; but the massive soapstone is, on account of its infusibility, toughness, and smoothness, admirably adapted to its important uses in the construction of stoves, sinks, aquaria, etc.

Pryophyllite Schist.—This is the massive or rock form of the aluminous talc — pyrophyllite. It is much like steatite (**93**) but rarer. Its principal uses are for slate pencils and tailor's chalk.

Pinite Schist.—This rather rare rock (**83**) is commonly to be regarded as an altered form of massive feldspathic rocks. Thus the pinite schist of Milton (**87**) and other parts of the Boston Basin is simply a local alteration of the felsites. Fragments of this rock are common in the Roxbury pudding stone, although often mistaken for serpentine.

Greensand.—This rock consists chiefly of the mineral glauconite, mingled usually with more or less sand, clay, or calcareous matter. It is usually very friable, or entirely unconsolidated. Although it is most abundant in the newer geological formations, especially the Cretaceous (**88**) and Tertiary, it has a wide range in geological time. It is found in the Potsdam sandstone (**84**) and all later formations; and is, perhaps, the only one of the stratified silicate rocks now forming on an extensive scale in the ocean. Its value as a fertilizer, for which purpose it is extensively employed, is due to the potash which it contains.

Serpentine.—The rock forms of serpentine are presented under a great variety of conditions; and the opinions of geologists with regard to its origin are equally diversified. But, while it is very probable that some forms of serpentine, especially those most intimately associated with limestone, are true sedimentary deposits, it may now be regarded as certain that serpentine is chiefly an altered form of certain eruptive rocks, such as basalt and peridotite. It is, therefore, only as a matter of convenience, on account of the difficulty of distinguishing the sedimentary from the eruptive serpentines, that they are all classed here with the metamorphic rocks. This classification is also partly justified by

the fact that the serpentines of all kinds are usually intimately associated with the metamorphic rocks—the gneisses, schists, marbles, etc. Most of the specimens exhibited are clearly altered eruptive rocks. The specimens from the Bare Hills (**95-97**), Hartz Mountains (**82, 92**), Elba (**93**) and Italy (**89**), may be mentioned as typical examples of this class. The specimen from the Hoosac Tunnel (**91**) represents one of the most important masses of serpentine in New England. Serpentine irregularly veined with magnesite is known as *verd antique* (**81**).

Chlorite Schist.—This rock stands in the same relation to the mineral chlorite that steatite or talc schist does to talc; and most of the specimens are so nearly pure chlorite as to be quite suitable for the mineral cabinet. Like steatite, the structure may be either massive, as in the very pure chlorite from Cross Island (**85**), or schistose (**81–83**).

It often contains more or less hydromica (**83**), and is sometimes distinctly talcose (**86**) as well as quartzose, feldspathic, and argillaceous. Chlorite schist and steatite are sometimes closely associated, as at Rowe, where they are worked in the same quarry (**84**), and the massive forms of chlorite schist have in a limited way the same uses as steatite. It is quite certain that chlorite schist, like serpentine, is sometimes, if not usually, an altered eruptive rock. This origin appears very probable for the foreign specimens especially (**86**).

(2) Eruptive or Unstratified Rocks.

The rocks of this great class are formed by the cooling and solidification of materials that have come up from a great depth in the earth in a melted and highly heated condition. When the fissures in the earth's crust reach down to the great reservoirs of liquid rock, and the latter wells up and overflows on the surface, forming a volcano, then we may, as has been explained on page 43, divide the eruptive mass into two parts: first, that which has actually flowed out on the surface, and cooled and solidified in contact with the air, forming a volcanic cone or sheet; second, that which has failed to reach the surface, but cooled and solidified in the fissure, forming a dike.

It has been shown that while the volcanic rocks or true lavas and the plutonic or dike rocks are essentially identical in composition, there is a marked difference in texture due to the widely different conditions under which the two classes have cooled and solidified. The plutonic or dike rocks solidify under enormous pressure, and this makes them heavy and solid — free from pores. They are, at the time of their formation, surrounded on all sides by warm rocks, which causes them to cool very slowly, and allows the various minerals time to crystallize.

The volcanic rock, on the other hand, cools under very slight pressure; and the steam, which exists abundantly in nearly all igneous rocks at the time of their eruption, is able to expand, forming innumerable small bubbles or steam-holes in the lava. Cooling in contact with the air, the lava cools quickly, and has but little chance for crystallization. Hence, to summarize: plutonic rocks are solid and crystalline; and volcanic rocks are usually porous and uncrystalline.

Although the species and varieties of eruptive rocks which have been described are very numerous; yet it is sufficient for the purposes of general study and classification to recognize only four principal types in each of the two great divisions — the plutonic and the volcanic. The feldspars and feldspathides are, with unimportant exceptions, essential and often the principal constituents of the various eruptive rocks, so that while the rocks of this great class show a general agreement in composition with the gneisses among the metamorphic rocks, they rarely exhibit any relationship in this respect with the schists. Again, the four principal types of the plutonic rocks are of strictly analogous and almost identical composition with those of the volcanic rocks. Hence it is clear that in a general view we may consider that, so far as mere composition is concerned, and taking no account of their origins, the combinations of minerals observed in the gneisses are repeated under different conditions and textures among the plutonic rocks and again among the volcanic rocks. The four principal feldspathic rocks in the metamorphic series, as we have seen, are gneiss, stratified syenite, stratified diorite, and norite. The corresponding eruptive types are as follows: plutonic rocks — granite, syenite, diorite, and diabase; volcanic rocks — rhyolite, tractyte, andesite, and basalt. The first two members of each series are acidic in composition, and the last two are basic.

The eruptive rocks are arranged after the manner of the metamorphic class; the plutonic division occupying the two upper shelves of sections 19–21, with the acid groups (granite and syenite) on the left, while the volcanic division occupies in the same manner the two lower shelves and the bottom of these sections.

Plutonic or Dike Rocks. — This division embraces, as already explained, all the eruptive or igneous rocks which, while in a liquid condition, have broken into but not entirely through the superficial portions of the earth's crust. Hence they are also known properly as the irruptive rocks. The plutonic rocks, having cooled slowly and under great pressure, are generally, like common granite, characterized by a dense and crystalline texture; and, other things being equal, the coarseness of the texture is proportional to the depth below the surface at which the rock has solidified. Hence, since the plutonic rocks can only be exposed as the result of erosion, which is a slow process, it is plain that, in general, the degree of crystallization affords a measure of the relative age of the rock and of the amount of erosion which the region has suffered since it was formed.

In the more elaborate lithological classifications we must recognize not only minor differences of composition and especially of alteration, but also, to some extent, differences of age, and the somewhat concomitant variations in the forms of the masses. The regular wall-like dikes are especially characteristic of the relatively modern, superficial, and fine grained trappean rocks; while the extremely irregular outlines are found chiefly with the older, deep-seated, and coarsely crystalline granitic rocks.

Granite. — Granite is the most abundant, the most varied and the most useful of all the eruptive rocks; but the specimens on the first and second shelves of section 19 represent only a few of the numerous varieties. As with gneiss, we properly begin with the simplest or binary form of granite, which consists of the essential

minerals — quartz and feldspar — alone or without important accessories (**6–10**). The most finely granular varieties of binary granite are called aplite (**7–8**) or eurite (**10**). The beautiful Dedham granite is a good illustration of these. Many of the coarser red granites, such as those from the coast of Maine, New Brunswick, and Scotland (**12**) also belong here.

The specimens in the first row on this shelf represent the hornblendic variety (**1–5**), which was formerly called syenite, and is still often, but incorrectly, known by that name. The true syenite, as that term is now defined by lithologists, differs from granite in not containing any quartz. (See the next section.)

The original syenite (hornblendic granite) from the locality to which it owes its name — Syene, Egypt — is well exhibited in some of the ancient Egyptain sculptures in the Museum of Fine Arts, and in the Egyptian obelisk in Central Park, New York. Two of the hornblendic specimens (**2, 4**) illustrate the porphyritic texture in granitic rocks; while the specimens from Malacca and the Antarctic regions (**5, 11**) are interesting chiefly on account of the localities. It is to the hornblendic variety that most of the granite quarried at Quincy, Rockport, Peabody, etc., should be referred.

The specimens on the second shelf (**21–34**) belong chiefly to the micaceous variety, which is by far the most abundant and important form of granite. They show the usual range of textures, and the other features are sufficiently explained on the labels. The drawing (**3**) shows the appearance of a thin section of granite when magnified in polarized light; and attention is called particularly to the liquid inclusions in the brightly colored grains of quartz, and to the fact that the extreme irregularity of the forms of the quartz proves that it was the last of the principal constituents to crystallize.

Syenite. — As compared with granite, the true syenite or quartzless granite is a rare and economically unimportant rock. The majority of the specimens (**1–6, 26,** section 20) represent the principal variety, which is composed of the essential mineral — feldspar, chiefly red and gray orthoclase, and hornblende. The hornblende is not infrequently replaced partly or wholly by black mica (**3**) ; and the orthoclase in part by plagioclase or by elaeolite, one of the feldspathides (**4**). Zircon is one of the most interesting accessories, forming the variety zircon syenite (**5**). *Greisen* (**6**) is a massive aggregate of quartz and mica, and may be referred to in this connection, although its eruptive origin is very doubtful.

Diorite. — This is one of the most abundant rocks in Eastern Massachusetts; it presents, however, but few distinct or interesting varieties and it is of no economic importance. For the most part it is a finely crystalline and monotonous aggregate of plagioclase and hornblende with more or less black mica and epidote (**11–16, 31–37**) ; but one of the specimens (**14**) shows that more interesting accessories sometimes occur. *Miascite* (**32**) and *kersantite* (**38**) are rare species belonging in this part of the classification.

Diabase. — Broadly but correctly defined, diabase is the most important and interesting of the basic plutonic rocks. It is the principal dike-forming rock of this region. Nearly all the more or less regular or wall-like "trap" dikes cutting through the slate, conglomerate, granite, etc., about Boston and along the coast, consist of diabase and it is, therefore, a rock of especial interest for students of our local geology. Although

normally it is a crystalline granular aggregate of plagioclase, augite, and magnetite, it presents many varieties of texture and composition. It may be very coarsely crystalline or porphyritic, or quite compact; the compact or aphanitic forms being the typical trap which occurs so abundantly in the smaller dikes (**1**, section 21). The porphyritic diabase (**2, 4–5**) is sometimes of interest as an ornamental stone; and some of the antique porphyry (**10**) belongs here. Chrysolite is not an uncommon accessory mineral (**9**) in diabase, and it is interesting especially as making the identity of composition of diabase and basalt more complete. The augite, especially in the older and more coarsely crystalline diabase, is often partly or wholly replaced by diallage or hypersthene, giving the varieties or sub-species gabbro (**24–29**) and hyperite (**25**). Greenstone, although a much abused lithological term, may now be most properly used to designate the important variety of diabase in which the original minerals, and especially the augite, have been largely changed to chlorite or similar green hydrous silicates (**21, 26**). The serpentinic diabase (**36–37**) may be regarded as a special phase of greenstone.

The drawing (**3**) represents a thin section of typical diabase magnified in polarized light, and shows especially the slender twinned crystals of plagioclase. *Peridotite* and *dunite* or *olivine rock* (**31–35**) may be classed with the plutonic rocks, although it is probable that they belong partly in the volcanic division. Peridotite is essentially a granular aggregate of chrysolite or olivine, with often more or less plagioclase, augite, magnetite, chromite, etc. In fact it may be usually regarded as a very highly chrysolitic diabase; *i.e.*, as a diabase in which this accessory has become the chief essential constituent.

Volcanic Rocks or Lavas. — The general characters of the true lavas or surface flows have been noted. It may be added here that, while composed of essentially the same minerals as the plutonic rocks, there are some notable differences, such as the general absence of white mica; and that although composed in part at least, in every typical and unaltered example, of amorphous matter or glass, three more or less distinct varieties based upon texture may be recognized. These textural phases are: (1) *holocrystalline*, when the rock is composed chiefly of visible crystals, as in rhyolite, trachyte, andesite, and basalt; (2) *vitreous*, when the volcanic glass predominates, as in obsidian and tachylite; and (3) *devitrified or felsitic*, when an original vitreous texture has been changed to a stony or compact texture, as in petrosilex, felsite, porphyrite, and melaphyr. They may also be designated as the *crystalline*, *uncrystalline* or *amorphous*, and *semi-crystalline* forms of volcanic rocks. The first is illustrated by the specimens on the third shelf in sections 19–21; the second by those on the fourth shelf; while the devitrified or semi-crystalline rocks occupy the bottom of these sections. It is most convenient and natural, however, to treat this textural classification as subordinate to the acidic and basic groups; and in the following paragraphs each of the latter will be described as a whole.

Rhyolite and Trachyte. — The trachytic rocks, including rhyolite (**41–57**, section 19), which corresponds

in composition with granite, but is less commonly micaceous, and trachyte proper (**41–50**, section 20), which has very exactly the composition of syenite, are usually imperfectly crystalline to compact rocks, characterized by a somewhat porous texture and harsh or rough feel. All these features, as well as the characteristic light colors, are well illustrated by the specimens, which represent some of the more important regions in which trachytic rocks occur. The chief difference between rhyolite and trachyte is that the former contains quartz; but the minerals are often so imperfectly developed as to make it difficult to determine whether quartz is present or not. It shows distinctly in only a few of the specimens on the shelf (**48–49**). Sanidin, the clear form of orthoclase, found only in volcanic rocks, is well shown in several specimens of both rhyolite (**47**) and trachyte (**42**), being porphyritically developed in large crystals.

Obsidian.—Obsidian is a true volcanic glass and may be defined as either rhyolite or trachyte, chiefly the former, which has cooled so rapidly as to remain wholly or partially in an amorphous or uncrystalline state, being sharply distinguished from all other rocks by its perfect vitreous texture. The specimens illustrate the principal varieties, which are based chiefly upon the secondary textures. The plain, black glass (**61–62**, **66–67**, section 19) may be regarded as the most acid and the most typical obsidian, the gray and relatively opaque specimens (**65**, **70**) probably agreeing more closely in composition with trachyte than with rhyolite. No volcanic rock affords finer illustrations of fluidal lines or flow-structure than the banded obsidians (**64**, **68**).

The breccia texture (**69**) naturally results from the mass continuing to flow after the superficial portions of it have become solid. The vesicular texture (**61, 63, 65**, section 20) testifies with equal distinctness to the former fluid state of the rock; the vesicles or steam-holes being due to the expansion of the contained vapors when the rock was still molten. The most highly and finely vesicular obsidian is the typical pumice (**61**). The flowing of the frothy mass is often indicated by the elongation of the steam-holes, a more or less distinctly fibrous structure being developed in this way.

Although the typical obsidian is a true glass, and entirely amorphous, a more or less marked tendency to crystallization may be exhibited in several ways. First, in the development of microscopic crystals or crystallites, which may be so numerous as to amount to a partial devitrification of the obsidian, as in the variety *pitchstone* (**73, 75**). Second, in the aggregation of the crystallites in concretionary masses or spherules, as in the variety *spherulite* or spherulitic obsidian (**70**, section 19, and **64**, section 20). Third, in the development of true, macroscopic crystals, as in porphyritic obsidian (**72, 76**). *Perlite* (**62**, section 20) is an interesting structural variety due to local contraction and concentric splitting during cooling.

Petrosilex and Felsite.—The felsites or felsitic rocks include petrosilex, which agrees in composition with rhyolite and the more acid and typical obsidian, and felsite proper, which shows a similar agreement with trachtye and the less acid obsidian. In other words, the felsites, as previously explained, are either acid lavas which have cooled too slowly to permit the formation of a true glass (obsidian) and yet too rapidly

for the development of a distinct crystalline texture (rhyolite or trachyte); or they are altered obsidian, *i.e.*, obsidian which has suffered devitrification subsequently to its original cooling. The intimate genetic relation of obsidian and felsite is seen in the fact that nearly every variety or structural feature of the former is observed in the latter. The felsites, have, like the granites and traps, a large and varied development in the region about Boston, ranking as, perhaps, the most interesting and beautiful feature of our local geology. The most typical petrosilex and felsite exhibit the semi-crystalline or felsitic texture throughout, as in the so-called "Saugus jasper" (**81–86**), which may be compared with the plain glassy obsidian. Every phase of the flow-structure of obsidian is most perfectly reproduced in the banded petrosilex (**83, 87–88**) and felsites (**90, 98**); and the same is substantially true of the brecciated (**95–97**), concretionary or spherulitic (**99**), and porphyritic (**84–85**), textures. The felsites, however, are much more commonly porphyritic than obsidian, and unlike obsidian are often porphyritic with quartz as well as feldspar, giving the variety quartz porphyry (**85–86**, section 20), which frequently exhibits a gradual passage into granite (**92–93**). The porphyritic texture is so characteristic of these rocks that they are commonly known as porphyries; and among our native varieties there are some which appear to be as suitable as the antique porphyry (**81–84**, section 20), for architectural and ornamental uses.

Andesite and Basalt.—These are the basaltic, as distinguished from the trachytic, rocks, and have, as the labels show, approximately the composition, respectively, of diorite and diabase. A glance at the specimens shows that they are much darker colored than the trachytes, although generally similar to them in crystallization and texture. The andesites (section 20) differ chiefly in the proportions and nature of the hornblendic and feldspathic constituents, ranging from highly feldspathic varieties (**51, 53**) to those which are black with hornblende and magnetite (**52**). The presence of quartz gives the variety *dacite* (**59**).

Basalt (section 21) is more varied. As regards texture it may be crystalline, compact (**47**), or vesicular (**58**). Chrysolite, in clear glassy green grains, is the chief accessory mineral (**45, 48**). In the lavas of Mt. Vesuvius and some other volcanoes the plagioclase is partly replaced by leucite in gray isometric crystals (**50, 53**). Nephelite and other feldspathides also play the same role. The basalt from Lassen's Peak (**52**) is interesting on account of containing quartz as a prominent constituent. Many lavas have an historical interest. This is especially true of the eruption from Mt. Vesuvius in the year 79 (**59**), the first recorded eruption of that crater, and the one which overwhelmed the cities of Pompeii and Herculaneum.

Tachylite.—This species includes the more or less distinctly amorphous or glassy forms of both andesite and basalt, standing in the same general relation to these rocks that obsidian does to rhyolite and trachyte. It is usually, however, a much less perfect glass than obsidian, the basic crystallizing more rapidly and perfectly than the acidic lavas. The most glassy tachylite is quite

opaque, resembling certain black furnace slags (**62, 64**, section 21). The flowing of the liquid lava is commonly indicated by very characteristic surface features (**61**, section 21, **71**, section 20). Tachylite is very generally vesicular or scoriaceous, as seen in most of the specimens, although rarely so thoroughly vesicular and spongy as obsidian in the form of pumice. The almost perfect liquidity of the molten lava, even when rapidly cooling, is beautifully illustrated by the stalactitic forms (**69, 73–74**) resulting when the lava falls, drop by drop, from some overhanging surface. Pele's hair (**65**) is the interesting variety produced when the highly liquid lava is caught up and blown by the wind, a veritable frozen spray.

As in basalt, the most important accessory mineral is chrysolite (**74–75**). Several of the specimens represent flows whose dates are known; and some of these are quite recent, as the great eruption of Mauna Loa in 1886 (**74–75**), and the small eruption of Etna in 1883 (**66**). Vesuvius is now almost continuously active, and the specimens of fresh lava thrown out in 1883 (**67**) might be duplicated at almost any time. Some of the older dated specimens are interesting at least for the great magnitude of the eruptions which they represent (**75**, section 20). Although the fresh basaltic lavas are naturally dark colored or black, they commonly weather reddish, through the peroxidation of the iron (**74**, section 20).

Porphyrite and Melaphyr.—These may be regarded as semi-crystalline basaltic lavas, or devitrified forms of tachylite; holding very much the same relations to this rock that petrosilex and felsite do to obsidian. Comparatively modern and unaltered forms of each are well illustrated by the dark specimens from Germany (**91**, section 20, **81**, section 21). In a highly altered condition, in which the original augite, feldspar, and olivine have been largely changed to epidote, chlorite, quartz, etc., they are extremely abundant rocks in the vicinity of Boston, including the most of the basic lavas of the Boston Basin. These ancient lavas exhibit nearly every structural feature observed in the products of modern craters, except that the steam-holes or vesicles have been very generally filled up by the secondary minerals —quartz, epidote, etc., changing the amygdaloidal to the vesicular texture (**84-85**). They are very commonly brecciated, after the manner of recent lavas (**86**); and in some cases the characteristic surface contours have been preserved.

Vein Rocks.

All rocks are not embraced in the sedimentary and eruptive divisions, but there is a third grand division, which it is deemed best to include in the illustration. These are the vein rocks. They present a large number of varieties, and yet, taken altogether, form but a small fraction of the earth's crust. They are, however, the great repositories of the precious and other metals, and hence are objects of greater importance to the miner and practical man than the eruptive rocks, or, in some parts of the world, even than the sedimentary rocks. The specimens illustrating this division of lithology occupy sections 22 and 23, between the windows.

The vein rocks, like the plutonic rocks, occupy fissures in the earth's crust intersecting the stratified formations; but the fissures filled with vein rocks are called veins, and not dikes. The mode of formation of a typical vein has been explained on page 48.

The water circulating through the earth's crust is often saturated with its various mineral constituents, and veins are formed by the deposition of the dissolved minerals in fissures. One of the most important characteristics of the vein rocks, as a class, is the great variety which they present; for nearly every known mineral is embraced among their constituents; and these are combined in all possible ways and proportions, so that the number of combinations is almost endless. The solvent power of the subterranean waters varies for different minerals; and appears often to be greatest for the rare species. In other words, there is a sort of selective action, whereby many minerals which exist in stratified and eruptive rocks so thinly diffused as to entirely escape the most refined observation are concentrated in veins in masses of sensible size; and our lists of known minerals and chemical elements are undoubtedly much longer than they would be if these wonderful storehouses of fine minerals which we call veins had never been explored. As a rule, the minerals in veins form larger and more perfect crystals than we find in either of the other great classes of rocks. This is simply because the conditions are more favorable for crystallization in veins than in dikes or sedimentary strata. In both dikes and strata, the growing crystals are surrounded on all sides by solid or semi-solid matter; and, being thus hampered, it is simply impossible