

that they should become either large or perfect. In the vein, on the other hand, there are usually no such obstacles to be overcome; but the crystals, starting from the walls of the fissure, grow toward its center, their growing ends projecting into a free space, where they have freedom to develop their normal forms and to attain a size limited only, in many cases, by the breadth of the fissure. With, possibly, some rare exceptions, all the large and perfect crystals of quartz, feldspar, mica, beryl, apatite, fluorite, and of minerals generally, which we see in mineralogical cabinets, have originated in veins. Those fissures which become the seats of mineral veins are really Nature's laboratories for the production of rare and beautiful mineral specimens; and hence the vein rocks are the chief resort of the mineralogist, to whom they are of far greater interest than all the eruptive and stratified rocks combined.

The leading characteristics, then, of the vein rocks may be summarized as follows: (1) They contain nearly all known minerals, including many rare species and elements which are unknown outside of this class of rocks. (2) These mineral constituents, occurring singly and in association, give rise to a number of varieties of rocks so great as to baffle detailed description. (3) They exceed all other rocks in the coarseness of their crystallization, and in the perfection and beauty of the single crystals which they afford.

The arrangement, and to a large extent the nomenclature, of the specimens is essentially mineralogical, beginning with the sulphides and ending with the silicates. They have been selected with a view to showing a few

only of the more typical and interesting minerals and associations of minerals occurring in veins. Some show complete sections of small veins (gypsum); and the large geode may be regarded as an incomplete vein. Others exhibit characteristic vein structures, with prismatic crystals perpendicular to the walls (graphic granite and quartz). The columnar and stalactitic forms (limonite and calcite) manifest the same general tendencies.

These two sections may be regarded as one, the specimens and numbers continuing across on each shelf from 22 to 23. The first specimens are examples of the metallic ores, which occur very largely in veins. The galenite (1) represents the peculiar and important lead veins in the limestones of the Mississippi Valley. The zinc ore (3) and copper ore (4) are from veins of more normal type in the crystalline rocks of the East. Pyrite (5) is the most important mineral in many of the auriferous veins of the Rocky Mountains; the more massive specimen (6), however, represents the great vein in Rowe, Mass., which is mined to get pyrite for the manufacture of sulphuric acid. The next specimens (11-12) are additional examples of copper and zinc ores, which show by their forms that they must have come from veins. The iron ores are mainly, like the coals and bitumens, bedded rocks, but these examples of specular hematite (13-14), magnetite (67), and limonite (81) are quite clearly the products of veins, and albertite (15), a variety of asphaltum, is known to fill fissures cutting across the strata. The large mass of native copper (91) is from a vein and illustrates one important mode of occurrence of the copper in the Lake Superior mines.

Calcite, although occurring chiefly in the form of a stratified rock (limestone), is also an important vein-forming mineral. It is often found coarsely and beautifully crystallized (26, 36-37); but it is still more commonly massive or quite compact, as in the cavern deposits—stalactites (32) and stalagmites (31). This

is essentially the origin of the beautiful onyx marbles (21-22). What has been stated for calcite might be repeated for gypsum (22-24, 28), and barite (33, 35). Apatite, in its mineral forms (25-27), occurs chiefly in veins, as the large and perfect crystals indicate. Fluorite (43) is another important vein-forming mineral, being, like calcite, barite, and quartz, a common constituent of metalliferous veins, the gangue or matrix of the ores. The vein forms of the most important of all the vein-forming minerals—quartz—are illustrated in a general way by the specimens (41-42, 44-45), the massive, vitreous quartz (45) being the most abundant. The large geode (82) may be regarded as a half-formed globular vein of chalcedony and crystalline quartz.

Among the ancient crystalline formations the veins consist very largely of either quartz, or quartz and various silicates, such as the feldspars, micas, etc. Of this character are the great veins of coarse or giant granite which in various parts of New England are quarried for commercial quartz (45), feldspar (53-56), and mica (74-75); and for crystallized cabinet minerals, such as tourmaline (71), beryl (73), etc. The large group of beryls in quartz in the Vestibule shows with what a lavish hand Nature has furnished these mineralogical store houses, while the enormous single crystal of beryl shows how favorable the conditions have been for the development of the mineral individuals. Graphic granite or pegmatite (62-64, 72) is a very characteristic structural feature of the less coarsely crystalline portions of the vein granite. The large specimen from Fitchburg (65) shows a more nearly complete section of a granite vein; and the highly micaceous specimen from the Black Hills (61) represents the great tin-bearing vein in which crystals of spodumene thirty to fifty feet in length and one to three feet in diameter have been observed.

PETROLOGY.

In lithology we investigate the nature of the materials composing the earth's crust—the various minerals, and aggregates of minerals, or rocks; while in petrology we consider the forms and modes of arrangement of the rock-masses, — in other words, the architecture of the earth.

Petrology is the complement of lithology, and in many respects it is the most fascinating division of geology, since in no other direction in this science are we brought constantly into such intimate relations with the beautiful and sublime in nature. The structures of rocks are the basis of nearly all natural scenery; for what we call scenery is usually merely the external expression, as developed by the powerful but delicate sculpture of the agents of erosion—rain and frost, rivers and glaciers, etc.—of the geological structure of the country. And to the practised eye of the geologist, a fine landscape is not simply a pleasantly or grandly diversified *surface*, but it has *depth*; for he reads in the superficial lineaments the structure of the rocks out of which they are carved.

But, while the magnitude of the phenomena adds greatly to the charm of the study, it also increases the difficulty of procuring suitable illustrations for the museum and class room. Nature, however, has not been wholly unmindful of our needs in this direction; for she has worked often upon a very small as well as a very large scale; many of the grandest phenomena being repeated in miniature. Thus, we observe rock-folds or arches miles in breadth and forming mountain masses, and of all sizes from that down to the minutest wrinkle. So with veins, faults, etc.; and the wonderful thing is that these small examples, which may be placed in the cabinet, are usually, except in size, exactly like the large. Now the aim in this depart-