does, by preventing the escape of heat. The rocks below will in time grow warmer, since they are no longer superficial, and the growing accumulation of strata will also be heated. The whole mass will expand horizontally and vertically, the movement of subsidence will finally cease, and at last, as a consequence of the lateral strain, the horizontal strata will bulge and be ridged upward into the form of mountain masses.

More striking, perhaps, than the recent age of their constituent strata, and almost equally significant, is the folding that mountainous regions have undergone. We cannot do better than call attention here to the accompanying figure of that classical example, Mont Blanc. The strata, the reader will see here, have been folded and folded again, and their ridges have been denuded. If one takes the edges of a sufficiently flexible book and approximates the ends, one may imitate these foldings roughly, but they may be imitated still better by compressing layers of cloth laterally beneath a weight.

Now, unless all the elementary presumptions of geology are wrong, these folded strata must originally have been deposited horizontally. Since their deposition, therefore, their extremes have been brought nearer together. This puckering points unmistakably to a squeezing in from the sides. It has been calculated, in the case of the Alps, that points on either side of this mountain mass have been brought closer to one another by as much as seventy-two miles. In the case of the Appalachian Mountains the estimate is eighty-eight miles. We seem to have here, then, the clear record of the successive stages in such a process as is indicated in a simplified fashion by our Fig. 2 (A, B, C, D), in which A, B and C represent phases in a steady lateral compression and D repeats C, with some allowance for the action of sub-aerial denudation.

It is upon this aspect of mountain structure that Prof. Lapworth laid particular stress in his memorable address to the Geological Section of the British Association. He insisted upon the horizontal pressure and upon the strata giving to this strain at their weakest points, bulging up into ridges and furrows, and with further compression folding over, so that we get at last "over-folds" (Fig. 1), with an upthrust or arch limb, a middle portion, and a down thrust or trough limb. The middle portion must especially be under great pressure, and it may undergo crushing, or the fold may rupture and the arch slide forward over the fault to form a reversed fault or over-fault or thrust plane as in Fig. 5. The final result of this folding will be to strengthen the crust at the original weak point by more than doubling its thickness, and adjacent portions of the strata will then begin to pucker. So that in the flanks of the original fold fresh folding will arise until we get either a fan-like series (as in Mont Blanc) or a one-sided arrangement (Fig. 3) such as is displayed in the Appalachian and Jura Mountains.

The causes of these mountain foldings may possibly be the lateral stress due to local horizontal expansion, if the theory of Mr. Mellard Reade is correct. But a great number of geologists consider that the prime cause of these foldings, and indeed of mountain upheavals, is the contraction of the earth due to its secular cooling. As this contraction goes on, the cold crust has to accommodate itself to the shrinking interior, and in doing this it is necessarily crumpled and wrinkled. The great land masses and the great oceanic troughs of our earth, moreover, lie along lines of longitude. Winchell has attributed this north and south trend of the chief lines of crumpling to the directive influence of the tidal stress.

Prof. Lapworth, in his address, stated the case for the contraction theory of mountain origin in a remarkably vivid way. He called attention to the manner in which trough and ridge everywhere corresponded. For the upthrust of America, with its Mississippi Valley and its unilateral ridges of the Rockies and Appalachians, we have the Atlantic with its division by the Dolphin ridge into two parallel troughs; and corresponding to the broad uprise of the older continents we have the great depression of the Pacific. Coming to the shorter transverse foldings, the Alpine mass had for its trough the Mediterranean; and Central Asia the southward deep of the Indian Ocean. This "undulation" of the surface of the solid earth is far more in agreement with the theory of secular cooling than the theory of Mr. Mellard Reade.

On the other hand, there are those who consider the amount of folding we find in mountain masses, which must amount altogether to a diminution of the earth's circumference by many hundred miles, too great for their conception of the amount of contraction the world has undergone since the rocks in question were solidified. Moreover, in certain localities in Sweden and elsewhere, crumpled rocks are found lying on an undisturbed base. Prof. Reyer has recently propounded some novel and remarkably suggestive views in this matter.

He has conducted a series of experiments upon the behavior of artificial strata made of muddy material or plaster of Paris mixed with glue and variously tinted. These before complete consolidation were placed on boards slightly tilted (5° to 15°), and the arrangement was occasionally tapped to imitate earthquake shocks. There was a general sliding down and crumpling of the mass, such as might conceivably happen in the case of sedimentary rocks, and sections taken after hardening showed, in consequence of this sliding, beautiful imitations of folding, contortion and faulting such as are seen in mountain chains. Such experiments as this might very easily be repeated by teachers of geology or physiography. They certainly aid the imagination very greatly in thinking out these physiographic problems.

Prof. Reyer's conception of the development of a series of mountain folds, based on experiments of this kind, may be illustrated by the three figures given. While it harmonizes with Mr. Mellard Reade's hypothesis, it seems perhaps a little better adapted to explain complex crumpling of strata than does that supposition. A represents a continental mass, from which the sediments, C, D, E, accumulating in the sea, B, are derived. For manifest reasons, these will be thickest and coarsest near land, where the carrying power of water is at its greatest. Now, on the reasoning already given, this accumulation will finally

lead to upheaval, the uprise of strata being greatest in the region where the "blanket" is thickest. That is to say, the base is tilted. The strata consequently glide seaward and pucker up upon the tilted base (Fig. 7). Meanwhile the continental mass (A) is continually undergoing denudation, and the rocks immediately beneath, therefore, are cooling. We may say that the young land to the right is pulling the blanket off its older neighbor, the area, A. The cooling of A causes a subsidence and faulting, and the faulting, weakened, and sinking crust is there least able to resist eruptive material, so that at last (Fig. 8) a volcanic chain, F F F, may grow up behind the fold chain.

This, briefly, is the story suggested by Prof. Reyer.

SECTION OF MONT BLANC.

a story also fairly consistent with existing mountain structures. But it need not be regarded as a theory absolutely opposed to that so clearly propounded to the English student by Prof. Lapworth. The heating effect of deposition suggested by Mr. Mellard Reade, the crust contraction to which Prof. Lapworth gives prominence, the "gliding" of Prof. Reyer, are all causes that must operate. Prof. Reyer's theory may explain many cases of folding, Mr. Mellard Reade's many cases of upheaval, and yet the great wrinkles on the face of Mother Earth may be due to her withering as the warmth of her youth departs from her.

Clearly, from what has been said, volcanic phenomena are a mere incident in the growth of a mountain chain. They do not, for instance, appear to have played a leading part in Alpine history, and the Rocky Mountains were already elevated before the great trachytic and basaltic outflows of that region occurred. Volcanic forces cannot, therefore, for one moment be regarded as standing in a causative relation to mountain building. Nevertheless, in the

Andes and the Himalayas the abundant presence of volcanoes is food for thought. However, the question of the causes of volcanic action scarcely belongs to this paper.

Here we may allude to a third feature of mountain structure. It emphasizes the enormous pressures to which the folded rocks were subjected. It is the alteration of the microscopic structure of these rocks.

We find, for instance, clays, with all their once highly-pigged particles, twisted round into a direction at right angles to the force of compression, so that they can be split up into laminae, and are no longer clays but slates. Limestones lose the traces of their organic relics and become recrystallized as marble. Some rocks are seen with their constituent minerals literally crushed and rolled over and into one another, as though they had been through a colossal crushing mill (mylonitic structure). The quartz of granite, for instance, is powdered, the feldspar cracked and reduced to cloudy particles, the mica twisted and shredded. The rock has also been, as it were, *masticated* in the presence of in-soaking water. Old minerals have been dissolved out, fresh ones formed.

In some cases a parallel order of the minerals has been induced. It is as if the rock had become plastic under these stupendous stresses, and that we had here its lines of flow. Nothing could be more eloquent of the irresistible nature of the mountain-making forces. It is interesting too to notice how we have thus repeated, in a thin flake of rock that would scarcely weigh a grain, the same story of enormous lateral pressure that we find in considering the stratigraphical structure of an Alpine *massif*.

To summarize our deductions, we have in the history of every great mountain chain the following phases. We can do without any appeal to "old Seismos" now to account for the elevation. A long

period of quiet subsidence and deposition of sediment is followed by upheaval. There is a process of lateral compression relieved by a bulging, the formation of a ridge or ridges, with troughs on either side. Probably there are no great paroxysms; the steady squeezing and upward creep goes on day by day, year by year, age by age. Strata are imperceptibly thrown into bends, into loops, the foldings are heaped up one above the other, overfolds are formed. The rising mass slowly becomes a prominent terrestrial feature. Stresses, culminating day by day, are at last relieved by the formation of faults and thrust planes, and as the ruptured strata slip there are earthquakes. Rocks are crushed and metamorphosed, softened, moulded, possibly even liquefied. There may be volcanic outbursts along the axis or upon the margins of the rising area.

The emerging mass becomes subjected to denudation. In the main troughs which will be sinking beside the rising ridge, forming seas or lakes, sediments will accumulate. Presently these areas cease to subside and become involved in a greater movement of elevation, as is shown by the Swiss *molasse* and the Siwalik rocks on the Himalaya flanks. So the vast growth continues. Strata tilted on its rising shoulders slide and are crumpled. Above, the snow and glacier are soon at work—unequal heating by day and frost by night, rain and wind splinter the metamorphosed upturned rock masses into peak and pinnacle, cirque and precipice. Thus in the course of ages the mountain chain attains its prime, and a brief equilibrium follows.

But the forces of lateral pressure and upheaval are dying away or they have found a weaker area elsewhere. The volcanoes become extinct, the earthquakes less violent and less frequent. Every moment a hundred streams carry away their quota of material suspended or dissolved. So the period of decay sets in. From the still eruptive Himalayas we may turn to the more quiescent Alps, from there again to the worn-down masses of Scandinavia and Scotland, from there to the still more ancient mountain range half buried beneath the strata of Wales and central England; and so the story ends at last as it began, in sedimentation in the sea.

In conclusion, attention may be called to the rather remarkable fact that in the moon no great meridional mountain ridges, such as one might expect from the analogy of the earth, are to be traced. Neither have the mountains of the moon so distinctly the linear ridge-like arrangement characteristic of terrestrial mountain axes. One might have anticipated, on the contrary, in the absence of an atmosphere and atmospheric denudation and with feeble gravitational attraction, that broad regions of crust folding would have been more conspicuous than on the earth. It may be that these features have been masked by the subsequent precipitation of the lunar atmosphere; but the volcanic character of lunar scenery is hardly consistent with this hypothesis. This, however, is a question for the astronomer to consider.—*Knowledge*.

THE NEW PHYSICAL GEOGRAPHY.

By RALPH S. TARR.

AMONG the many instructive lessons which the study of the geology of the far West has taught, perhaps the most important is the fact that physical geography and geology are inter-related sciences. If one examine a text book of physical geography, he finds that it deals in the main with descriptions and statistics. A river is described as of three parts, the torrential, valley and flood plain portions; it has a divide, perhaps a delta, certain tributaries which rise here or there; it flows in this or that direction, and empties into a certain sea or ocean; and it has a given length and drains so many thousand square miles of surface. A mountain has a certain position, height and trend. In other words, the geographical side is fully presented; but the physical side is practically neglected.

Turning now to the monographs of Powell, Gilbert, Dutton, Russell and others, one finds that land form is regarded from the standpoint of origin and history, and that certain laws are stated by which these forms are derived. This is the nucleus about which much progress has been made toward the foundation of a science of physiography, or, if one prefers, of physical geography. While some Germans and Frenchmen and a few English writers have aided in the establishment of this science, it may, I think, be called essentially an American science, as it now stands. The writers named above, with Chamberlain, Salisbury, McGee, Davis and a few others, have shown how intimately land form is dependent upon structure and physical conditions, and that mountains, valleys, lakes and shore lines have all had a history which is readable, in part at least, by a study of their form and position. By them geology is made to serve in the explanation of land form, and land form is used to interpret geological history, so that the two sciences are made interdependent.

To each of these several writers much credit belongs for his part in the work, and it would be a task of much difficulty to award to each his full share of credit; but to Prof. Davis we owe much, not only for his original researches in the subject, but also formulation of a systematic statement of the history and development of geographical forms. This new science of physical geography he has been developing for years, with the aid of the other physiographers, and has established at Harvard a school of physical geography which is serving as a model for similar schools in some of the large colleges of the country. It is my purpose to state in outline some of the principles of this science, as I interpret them, though in a short article such a presentation must of necessity be incomplete.

Until recently river valleys have been looked upon as definite forms and in a measure unchangeable. Men who are still active in science, Prof. Dana, for instance, took part in the controversy which resulted in the now fully accepted view that river valleys were formed not by faults or cracks in the earth, or by floods, but by the streams themselves, and the general agents of denudation. When this view became firmly established, it was of necessity recognized that such valleys changed in form, but the exact nature of

the change has only recently been detected. That a river valley is young, mature or old, and that by certain peculiarities the relative age, or perhaps more properly the topographic age, can be recognized is a distinctly recent advance. The simplicity of the problem is obscured by the fact that accidents to river valleys are common, and tend to introduce complications, and this may account for the failure to recognize the operation of the law of development of valley form.

A river commencing the development of its valley has certain features which stamp it as young, and though these features may vary in detail, they are in general character the same, whether the development be upon plain, plateau or mountain. Climate, elevation, structure and altitude of the rocks all tend to introduce complications, and produce a marked effect upon the future development, but the main features are reproduced at the various stages of the valley history. In an arid climate the development is less rapid than in a moist climate, and the features of youth consequently remain longer. In a region of hard rocks the development is liable to be less rapid than in one of soft, incoherent, strata unless the load furnished to the river is more than it can carry, thus preventing it from cutting down toward base level. Moreover, the prominent features of youth are preserved in the former for a longer time than in the latter. The development differs in regions of horizontal rocks from that in a country where the strata are inclined, and a low plain will be much sooner reduced to a condition of topographic old age than a high plateau. The element of time, therefore, must be eliminated, and we must distinguish between old age in years and old age in form.

For the sake of simplicity, I will trace briefly the history of a plain of moderate elevation, following in this the example of Prof. Davis in his first article upon the subject. Such a plain would, in all probability, have a general slope in a certain direction down which the drainage would flow, eventually gathering into a channel. This channel might be very irregular, but, in any event, it would be consequent on the original topography. In the hollows, if any existed, lakes would gather, which would act as temporary base levels below which the stream could not cut until they were removed. One of the first tasks of a river would, therefore, be the removal of lakes from its path, which could be done either by cutting down the barrier or filling up the basin, and probably both would cooperate. Lakes in a river's course are, therefore, signs of youth, though this condition is often produced by accidents, which rejuvenate the stream.

A river has for its work two tasks—the carving out of a channel and the transportation of material furnished to it by the disintegration of the rocks. By the two processes combined the river valley is formed and the general land surface lowered. The river itself in its channel does comparatively little work, the chief work being done by the destructive atmospheric agents and by the water as it percolates through the soil or gathers in little rills and moves down the slope. When by the gathering together of these supplies of water into rivulets, and later into rivers, a large body of water is accumulated into a single channel, there is a concentration of action along a narrow line which is the channel of the stream. Here the down cutting of land proceeds with comparative rapidity, but it is confined to the corrosive and erosive action of the river upon its channel bottom. By the slow swinging from one part of the valley to another, to some extent, the scope of this action is increased. The main action of the river, aside from its transporting work, is to lower its channel to as near base level as is possible; but the valley is broadened by the much slower and less perceptible action of subaerial denudation. That this is so is plainly shown by examining the prevailing valley type in arid and in moist regions. Where rains are rare the stream valleys are canons, because of this slower action, while in moist countries the prevailing valley type is broad, with gentle slope. The same form will come in time in arid regions, but it takes much longer to produce it.

When a stream is high above base level, as it would be upon the surface of our young plain, there is an important task before it which must be accomplished as rapidly as possible, and this is the lowering of its channel to as near base level as is consistent with its work as a transporter. Sometimes it is interrupted in this, and sometimes the channel is cut lower than it should have been, and an increased supply of sediment forces it to repair the error by building up its channel. This normal slope may be called the profile of equilibrium, and this may vary in form as the sediment supply varies. The form produced by this effort of the river is a narrow valley, with steeply sloping walls—a gorge or a canon, or a V-shaped valley. This results because the rate of down cutting is in excess of the general denudation. When, however, the channel can be lowered rapidly no longer, the rate of general denudation exceeds the rate of down cutting and the valley walls become farther apart and lower, and a broad slope is produced. The narrow canon-like valley is, therefore, also a sign of youth.

At first our plain is only partly drained, and between the branches are flat-topped divides, upon which, perhaps, the water stands in swampy areas. Such flat-topped divides are seen in the valley of the Red River of the North, upon which the streams are still young, flowing in V-shaped valleys cut in the lake sediment of a body of water which disappeared as the ice retreated from the country. As the stream develops there is an effort to reclaim all land and bring it into a well drained condition; and by the headwater erosion of the streams this is accomplished, so that water which falls upon any part of the land finds a way prepared for it and the divides are reduced to ridges.

A profile of equilibrium must be one not only without basins but also without abrupt descents, and therefore a stream which has falls or rapids in its course must be considered as young, for it has not produced a profile of equilibrium. Waterfalls may be original in the path of the young stream, but more commonly they are developed by the stream as it lowers its channel toward base level. A spur of hard rock, such as might occur in its path in a region of tilted strata, or in a region traversed by dikes, would cause falls, but the great majority of rapids and waterfalls in a river course occur where the rocks are horizontal and

of alternating hardness. They occur here more abundantly than elsewhere, chiefly because as a fall is produced at a given point it retreats up stream, and as long as the peculiar conditions last the fall lasts. In regions of horizontal strata the conditions exist over the entire area, but in vertical strata the stream finds itself of the rapid or fall when it has at this point lowered its valley to the profile of equilibrium. In the case of Niagara the fall was at the bluff near Queenstown, but it has retreated seven miles up stream; while if the fall had begun in tilted rocks, it would have existed practically no longer than it was necessary to cut down to the present level in the neighborhood of the original fall.

In speaking of the age of a river valley it is necessary to bear in mind that in different parts of the stream the topographic form is different. Then the development is more rapid near the mouth than at the headwaters, and here falls may linger even after topographic maturity has been reached lower down the valley. Then, too, the headwaters may be in mountainous regions, where the task before the stream is much greater, while the power of performing it is reduced.

Youth, with its lakes, falls, and narrow valleys, gives place to maturity, where these have disappeared, except perhaps in the upper tributaries. The valley broadens out, particularly in its lower portion, and the channel slope is moderate. Its chief work is now that of a transporter of drainage and of sediment, and this it accomplishes as long as the land will furnish the sediment; but eventually old age must come to it, when the land is reduced to low hills and shallow valleys and the sediment supply is scant. This is a hypothetical stage, for we know of no truly old river valleys, though given time and long-continued freedom from land elevation, this must be the ultimate form of all land.

There are many minor details in the history of a river valley, and no valley has probably passed through this simple cycle, though all tend to do so and all show that they are in one part of it, usually the youngest. At the headwaters there are contests between opposing streams which may result in the robbing of one stream by another of some of its tributaries. Some streams find themselves superimposed upon a structure with which they are not in accord, and they slowly adapt themselves to the structure, and even mutually adjust their courses. These interesting and somewhat complicated phenomena we cannot consider here, but it may be said that they are sometimes apparent in the topography, or in the course of the stream, or in the surrounding conditions.

The chief complications which occur in the history of a stream valley are those arising from external accidents. The growth of a mountain across a valley may dam up, divert, or even reverse the course of a stream. A lava flow may do the same. Climatic change from moist to arid may greatly alter the conditions, and if in a great basin, the evaporation of a lake will not only give to the streams which flow into it the conditions of youth, but will introduce other peculiarities. Among other things a river system will be dissected by evaporation, as the Columbia has been by the cutting off of the tributaries which now empty into the basin of the Great Salt Lake. Climatic change from temperate to glacial at first covers the surface of the country with ice, which, becoming a glacier, moves over its surface and when it disappears leaves it littered with drift which clogs the stream valleys, forms lakes and falls in the river course and diverts the streams from their valleys, forcing them to carve new ones. It is for this reason that our glaciated regions are the seat of so many lakes, falls and gorges; the country seems young, for it has been partly rejuvenated by the glacial accident.

By elevation of the land the streams are revived and given new work to perform; by depression the valleys are buried beneath the sea or fjorded, as upon the New England coast. These changes in the land and these accidents are frequent, and no sooner has a stream valley become partly perfected than a change comes and it is revived or retarded, and the cycle of development interfered with, and this is why we see no old stream valleys and why youthful characters are generally more common than mature forms. Knowing, however, what is the normal tendency, and knowing, also, something of the accidents to which stream valleys are subjected and what in general their effect is, we are often able to base a very correct interpretation of the history of a region from its valley form. A most instructive example of this is found in Dutton's monograph on the Grand Canon of the Colorado. Here the canon is of two parts, an inner narrow canon and an outer and upper broad one, the two being separated by a bench and the upper one being much more degraded than the lower one. Dutton's interpretation is this, that the stream cut down to approximately the level of the bench and here reached its profile of equilibrium, the land being then lower. For a long time the stream stayed at this level and the canon walls retreated farther from the stream and became degraded. Following this rose an elevation culminating in the present level of the plateau, and the inner canon is the result of this more recent work. This interpretation of the phenomena is in perfect accord with what one would expect to happen under such circumstances, and can be accepted as correct.

The study of land form upon the basis of history and development calls for a much more natural classification of topographic features than has been customary, and for a more scientific consideration of them. Lakes are, for instance, to be considered parts of river systems and should be classified upon this basis. There are, for instance, lakes of consequent origin, such as one would find upon a newly born plain. From the normal development of streams other lakes result, such as the ox-horn lakes, and those which are formed upon deltas by the irregular deposit of sediment. By the overburdening of a stream with sediment its channel may be built up, and the side streams laked or the side stream may throw a bar across the main stream and form a lake. All these may be called lakes of normal development. Other lakes, and by far the greater number, may be considered as accidental, for they result from some accident to the river valley. The rocks may be folded across its course, or a lava flow may dam back the stream, or a lake may result from glacial interposition,

Mountains also are capable of consideration and classification from the standpoint of origin. By the various kinds of folds or faults different types are produced, and these types all pass through a certain development the features of which may be defined and recognized. A young mountain has lakes, and its streams are in large part consequent upon the topography. A mature mountain has freed itself from these youthful characteristics, and its streams are in accord with the structure rather than the original topography; and, as in the Appalachians, we may find synclinal mountains and anticlinal valleys, instead of anticlinal mountains and synclinal valleys, as in young mountains like the Jura. The ultimate old age form would be a gently rolling plain like that which New England was, possibly, before the tertiary elevation, which allowed the streams to carve out their present valleys.

Shore lines also show certain forms as they proceed in development, and the system can be carried to all land forms. Such a study then gives to land form an added interest, for we see expressed by it an interesting history. During the past year I have written a series of articles for *Goldthwaite's Geographical Magazine*, descriptive of the history of river valleys, giving more detail than in the above a summarized statement of the subject. In closing the series I called attention to what seems to me a great fault among travelers and geographers, and it is a matter which I believe to be of sufficient importance to bear repetition, and I will close by quoting it.

"This is a great field and one in which nearly every intelligent person can do some work. Problems of interest lie at nearly every one's door. How are the plains, the hills, the mountains, the shores, the river valleys found, and by what stages have they come to their present condition? These are questions which every one can ask himself, and they are capable of solution. All these things have had a history, and although the early pages may be partly destroyed, or even lost, there are some pages that can be seen, and read. Even if they are incapable of being read and interpreted by the local observer, it is within his power to record an accurate description which will be of service to those who are more skilled in interpretation.

"A year ago I had occasion to examine carefully many hundred books and magazines, in the hope of finding such descriptions as would allow me to place some interpretation upon their history. This was for the purpose of finding examples of various phenomena in river development. To my surprise, I found that descriptions of sufficient detail were very rare, almost wanting in fact. The very points which were necessary to show the history were, as a rule, omitted. This was particularly true of works of travel and articles by travelers in geographical magazines. Distances, directions, elevations, descriptions of people and animals were very well given, but facts relating to physical geography were almost entirely omitted. I was finally forced to give up my search in geographical magazines and confine my attention to geological works, where in a measure I was able to find what I needed.

"To illustrate the poverty in this direction exhibited by geographic descriptions, I may say that a careful search through all the available literature failed to give any description which would furnish a clew to the cause for the remarkable bifurcation of the river Cassiquiare.

"Travelers may not be able to tell the age of a rock nor to show the relation of one series to another; but there are facts of great interest to a physiographic geologist or a physical geographer which are in plain sight. If the traveler would but describe what he sees and see what there is to describe, much of value could be added to his work."

THE ANNUAL EXHIBITION OF THE MINERALOGICAL DEPARTMENT OF THE BROOKLYN INSTITUTE.

THE well-lighted room at the Art Association Galleries in Montague Street was an excellent place for the exhibition which closed on the evening of Nov. 25. Previous exhibitions have all had interesting features; this, the fourth, was, I think, most significant on account of the number of choice specimens shown and the full representation of certain minerals in single collections.

Mr. Fred. Braun, the indefatigable collector and well known dealer, had a long line of cases filled with minerals gathered in New York City.

A rather large specimen of the narrow banded serpentine and calcite, called "eozoon," was found on One Hundred and Thirty-third Street; brown and black tourmalines in One Hundred and Fifty-ninth Street; cyanite with quartz and gneiss but with enough of its characteristic luster to be beautiful, as well as kaolinite in rather large masses, stilbite and titanite, were all picked up in One Hundred and Sixty-ninth Street.

The serpentines were the choicest specimens in Mr. J. Walker's case. They numbered eighty-five, and included a dark rich example of precious serpentine, one of pale green inclosing tufts of hornblende, and porcellophite, all from Stapleton, Staten Island. The rare and beautiful red specimen containing fine lines of olive green came from Lancaster Co., Penn. Mr. Walker also showed very fine natrolites, one of them was in stellate form on datolite; these, as well as the examples of apophyllite, heulandite, analcite, and pectolite, were all taken from the new tunnel at Shady Side, New Jersey.

A number of exhibitors showed specimens of prehnite from Paterson, New Jersey, which were rare on account of their size and depth of color. From there also datolite and stilbite have been brought. Mr. J. W. Freckleton's case contained some of the best of all the same varieties. Besides these, he showed a polished section of a stalactite, and small whole stalactites from Luray Cave, several highly iridescent botryoidal and stalactitic specimens of limonite, and small but clear rhodonites from Frank in Furnace, N. J. The large crystals of mica in his case were found at Edenville, N. Y. Among his most interesting objects were a long, thick mass of lava and some Pele's hair from the volcano of Manua Loa.

Dr. Joseph Hunt, former president of the department, brought from his large cabinet only Mexican minerals and gems. He showed opals with the yellow