Tavel writes more fairly with regard to the work done by other schools, and has wisely avoided the bitter methods adopted by Brefeld towards De Bary's pupils in some of his volumes, there still seems to persist a tone of under-valuation of the work of the Strasburg school. After all, it should never be forgotten that unless De Bary and his pupils had followed up the clue—however false it may prove—of the "sexuality" of the ascomycetes, the matter would have had to be investigated, and the fact that the Münster school is enabled to explain the phenomena seen in a new sense proves how valuable De Bary's careful observations were. Moreover, however probable Brefeld's view of the origin of the ascomycetous series is—and it is now the clearest story yet put forward—many of his own facts show that the *impossibility* of De Bary's view of a sexual origin, now lost, of the ascocarp, is by no means proved. Brefeld insists that the simplest ascocarp (*e.g. Thelebolus*) may be derived by suppressing the stalk and withdrawing the sporangium of a form like *Mortierella* into the investing barren hyphæ at its base; but the *zygote* of *Mortierella* also has investing hyphæ, and it would not be going much further to suppose the sporangium of the germinated zygospore of such a form to be similarly withdrawn into the invested capsule. This "wild hypothesis" would not alter Brefeld's view as to the homology of the ascus, or the derivation of the ascomycetes from the zygomycetes, but it would, and very materially, alter the attitude adopted towards the sexual hypothesis. We have termed the suggestion "wild," but it is possibly not more so than Brefeld's own hypothesis as to the nature and evolution of the chlamydospore, and we imagine that the last word has not yet been said on either matter. However that may be, Brefeld's laurels of results are such as are won by very few investigators and Von Tavel is to be congratulated not only for his own discoveries, but also on his book, which is by far the best exposition of the subject in existence.

H. MARSHALL WARD.

DAUBRÉE ON THE GEOLOGICAL WORK OF HIGH PRESSURE GAS.

A SERIES of experimental researches which promise to lead to important results, and which have already been applied by their author to the explanation of some difficult geological problems, have during the last few years been carried on by M. Daubrée. These experiments are concerned with the action of rapidly moving and high-pressure gas on rock masses, and lead to the conclusion that such high-pressure gas is a geological agent of no small importance. To carry out such experiments is no easy matter, but M. Daubrée has been fortunate enough to obtain the use of the apparatus used in the testing of explosives in the *Laboratoire Centrale des Poudres et Saltpêtres*. The high-pressure gas has been obtained by the explosion of gun-cotton and dynamite, the explosions being made in a steel cylinder with very thick walls, and closed at both ends with steel plugs. One of these plugs is fitted with a platinum wire, by the heating of which the charge can be exploded. The other, which under ordinary circumstances contains the manometer for measuring the force of an explosion, is modified so as to contain a block of the rock to be experimented on. A circular hole, moreover, is made at one end so that the gas, after traversing the rock, is allowed to escape. The rock, cut in the form of a cylinder, is supported between a steel stopper and the head of a piston. The charge of gun-cotton or dynamite usually filled a tenth part of the interior, and the pressures obtained were from 1100 to 1700 atmospheres. In one experiment the pressure was increased to 2300, and in another the still greater pressure of 2400 atmospheres was obtained. Many different kinds of rock were used, such as limestone, gypsum, slate, and granite, and each cylindrical block experimented on was cut through by a diametrical plane. In some of the experiments an additional very fine perforation was made along this plane.

As a result of the sudden shock of the explosions most of the rocks were fractured. In the case of the slate this resulted in faulting. The limestone and granite were broken up and crushed, but under the influence of the pressure the small fragments were quickly consolidated so as to resemble the original rock. This property of reconsolidating under pressure, thus shown to be possessed by rocks, seems analogous to the plasticity of ice observed by Tyndall.

All the rocks experimented upon, even the most tenacious, have undergone more or less erosion. The gases have disintegrated and pulverised them, and carried out the fragments. When their action was concentrated along certain lines, true perforations—that is to say, rounded channels more or less regular—were eroded through the blocks. In the case of a granite block the original perforation of 1·2 mm. was increased to a channel of 11 mm. The walls of these perforations after the explosions were found to be striated and polished. Sometimes the striations are parallel, like those produced by ice. At other times they spread in fan-form, and sometimes they are slightly curved.

The products of erosion are thrown out into the atmosphere, and an examination of the powder thus produced shows that a portion of the same possesses an interesting resemblance to the dust usually held to be of cosmic origin.

M. Daubrée applies the results of his experiments to explain the remarkable "diamond pipes" of South Africa. These diamond deposits are described by M. Mouelle in the *Annales des Mines* (tome vii. p. 193, 1885) as filling in cylindrical cavities of unknown depths in the rocks. These cavities appear to be cut out of the subjacent sedimentary or eruptive rocks, their upper parts are filled with a soft yellow decomposed rock matter, while below they contain hard volcanic conglomerate. They vary in size from a diameter of 20 to one of 450 m., and are originally surmounted by slight eminences, known as *kopyes* (little heads).

An interesting point about the general arrangement of the "pipes" is their occurrence along a straight line of 200 kilometres in length. Their walls, again, are smoothed and finely striated. These striations are often parallel, and indicate a powerful thrust from below upwards. No alteration is observable in the beds of shale forming the walls, except a slight elevation of their edges.

Thus in their general form, as long, narrow, cylindrical perforations in the earth's crust, they resemble the artificially produced perforations in the rocks experimented on. Their arrangement along a straight line suggests that they may have been opened along a line of fracture as were the perforations in the experiments. In the latter, the line of the eroded channel was determined by a very narrow perforation, and M. Daubrée suggests that in the former the positions of the "pipes" may have been determined in some cases by cross-fractures. The polishing and striation of the walls of the diamond pipes, again, is reproduced in the polishing and striation of the perforations in the experiments.

Another application of his experimental results made by M. Daubrée is to explain the opening out of the channels by which volcanic products reach the surface. Here, again, the linear arrangement of volcanoes, which has been so frequently pointed out, is noted as connecting volcanic vents with the experimental results. These are supposed to lie along lines of fracture, and each

volcano is supposed to have been determined by a cross fracture, or some other cause, facilitating the passage of gas at that particular point. That there are reservoirs of gaseous pressure of great power below the surface is evident from volcanic phenomena generally, and given a line of fracture, with cross fractures, or other predisposing causes, the experiments prove that high pressure gas is capable of opening out cylindrical passages by which molten rock matter and fragments may reach the surface. In this connection, M. Daubrée points out the occurrence of volcanic craters, of which the cones are formed entirely of rock fragments, and known as "craters of explosion." Thus, near Confolens, in Velay, there is a crater excavated in the granite, and of which the cone is formed entirely of granitic fragments.

M. Daubrée further applies his experiments to explain, (1) the fracturing and crushing of rocks; (2) the transport of their debris; and (3) their apparent plasticity.

Some further results show that the high pressures of some of the earlier experiments are not essential, but that complete perforations can be obtained with pressures of 1100 atmospheres. A cylinder of granite, cut in two by a diametrical plane, and bound together with a ligature of copper, was thus excavated along its whole length by an irregular channel which opened on the surface by two branches. In the case of a cylinder of rock of which the height greatly exceeded the diameter the perforation tended to the form of two cones united by their summits. The action of the gases is not confined to the drilling of the perforations, they have likewise grooved and striated the surfaces of the divisional planes of the cylinders. These striations and groovings are not produced, as might be supposed, and as M. Daubrée himself at first believed, by solid particles of rock carried by the gas, and use as graving tools. It appears, in fact, that the gases themselves are able to striate and groove the rock on their first contact with it.

As an interesting corollary to his experiments, M. Daubrée points out, that leakage from steam pipes may in a similar way cut through metal plates. An example is quoted in which metal exposed to the escaping vapour from a steam pipe (pressure, seven atmospheres) was channelled and striated: the resulting marks were similar to those of a saw or file. A valve on a steam pipe, again, has been attacked in a similar way.

All these groovings in the metal have received a similar polish to that given by emery.

In the experiments the gases have in general caused the fusion of the surfaces which they have attacked. Thus, on the surfaces of the divisional plane of a granite cylinder the felspar is melted into white globules forming small projections. The plates of mica have also been softened. Even the quartz has not escaped, but appears pitted in a manner which recalls the erosion produced by hydrofluoric acid.

Scales of the rock are detached by the very unequal expansion as by a sort of shock.

A black crust exactly similar to the crust of meteorites has been produced with certain stones.

The transport of the debris produced in the perforation of the cylinders of rock is applied by M. Daubrée to the history of certain cosmic dusts, and the sediments existing in some of the deeper parts of the ocean. In making the perforations the gases carry out a quantity of debris. A part of this was collected on sheets of cardboard covered with vaseline. The particles arrange themselves in concentric circles on the sheet according to their size. Some of the large particles pierce the cardboard, and even its supporting plate; the very fine particles are carried to a distance by the gases, which they render opaque. In the powder retained on the cardboard, two sorts of grains can be distinguished under the microscope. The first are indistinguishable from those produced by simple mechanical pulverisation; the second have a special character intimately connected with the particular conditions of the experiment.

Thus, in the case of granite, fragments of all three constituents, quartz, felspar, and mica, are found in the powder produced. But besides this, minute, perfect or nearly perfect, spheres are found. These are opaque and black, or slightly translucent and brownish, with a glistening surface, and sometimes furnished with a very characteristic neck. They are doubtless the products of fusion.

This latter part of the powder of erosion seems identical with certain parts of the atmospheric dust, and that found in the deeper ocean, as well as in geological formations of various ages, and which have generally been looked upon as of extra-terrestrial origin. Thus the conclusion is arrived at that, while part of the so-called cosmic dust is undoubtedly of extra-terrestrial origin, the opening of volcanic and other channels in the earth's crust by high-pressure gas has also played an important part in its production.

Eruptive breccias may also have been produced by the force of high-pressure gas, as shown by the fracturing, breaking up, and reconsolidating of the rocks experimented upon.

A more remarkable fact is the passing back of the pounded and broken-up rock to its original solid state under the influence of the same gaseous pressure. Thus the fragments of the rock in the experiments were found to have moulded themselves so exactly on the containing steel apparatus as to have acquired a specular polish. The rock had, moreover, taken the impress of striations upon the steel. Limestone thus regenerated showed a schistosity concentric with the cylinder. It seems obvious, then, that the rocks of the earth's crust, having so frequently been subjected to enormous pressure, and so often folded and contorted, must in a similar way have been broken up and regenerated.

Another experiment showing the apparent plasticity of rocks is as follows:—

A cylinder of Carrara marble without a preliminary fissure, but with furrows on one of the ends and on the side, was placed in the apparatus and subjected to a pressure of 2400 atmospheres. It was afterwards found to be perforated with a channel, and moreover to be accurately moulded on the containing apparatus so as to take the impress of the concentric striations as in former experiments. The furrows were completely effaced, while the diameter of the cylinder was increased and its height diminished.

The ejection of rocky matter through the channels perforated by high-pressure gas occupies another paper. In such high-pressure gas M. Daubrée contends we have an agent capable of accounting for the facts in conformity with his experimental results. Special reference is made to certain trachytic domes—as, for example, those of the high plateau of Quito—of which the form seems to indicate that the rock matter forming them was ejected in an almost solid state. These domes, M. Daubrée supposes, crown the summits of orifices (diatremes) opened by the passage of high-pressure gas, and were themselves afterwards forced out by the same pressure. Attention is called to the remarkable uniformity in height observable in groups of volcanoes. This is explained as the result of origin from one common reservoir of pressure. The height of the volcanic cone gives a measure of this pressure. On the other hand, the hypothesis likewise explains the difference in height in different regions. Thus, in certain cases, reduction of pressure would be effected by lateral escape of gas, as happened in certain experiments in spite of the utmost care. A similar reduction of pressure may have occurred through the blocking of the channels of egress of the gas. This, too, occurred in certain of the experiments, notably when gypsum was the rock experimented on. With this rock the channel

opened by the gas was quickly closed again by the rapidity with which the triturated rock resolidified. The paper concludes with a suggested application of the hypothesis to the cones and craters of the moon.

In another paper M. Daubrée returns to the subject of the flow of rocks under high pressure. With respect to this point he remarks that, in certain previous experiments, the rock not only accurately moulded itself to the apparatus, but also formed thimble-shaped protuberances outside it. Further experiments were conducted with round plates placed one upon another, instead of the former cylinders. Lead plates were first experimented on, and then these along with plates of rock. One of the most interesting results obtained was the production of little "eruptive cones" of lead or rock outside the apparatus. In one case the protuberance reached the height of 36 mm. After the experiments, some of the plates were found outside the apparatus in the form of circular capsules, so closely fitted into one another as to appear soldered. Some of the lead plates remaining in the apparatus were cut through in their central parts as with a punch. The thickness of these perforated plates was found to be diminished on their borders, and increased in their central portions. This effect may be compared to what occurs in many cases with contorted rocks. At the same time spaces were here and there formed between the plates thus united. Daubrée draws attention to the analogy between these spaces and those occurring between separate strata among contorted rocks, and which are often filled with metallic substances. Lamination was also produced in the plates of rock.

As a general designation for the accumulations of rocky matter crowning the summits of all perforations in the earth's crust opened by gaseous pressure, whether trachytic domes, lava flows, scoriæ cones, or the kopyes of South Africa, M Daubrée proposes the term "ecphysema" (French, *ecphysème*," Gr., ἐκφυσημα).

To sum up M. Daubrée's results:—

(1) High pressure gases from below are able to open out channels in the earth's crust, by means of which the same pressure can bring to the surface various products.

(2) In forming such channels the gases may striate and polish the walls of the perforations in a manner recalling that of glacial action.

(3) The products of such erosions are partly of the nature of fine dust, which may be carried to immense distances, and a part of which resembles exactly the so-called cosmic dust.

(4) That the same high-pressure gas can fracture, break up, and pound a rock, and afterwards resolidify the same. That in thus resolidifying, the broken-up rock may mould itself accurately on the bounding walls of its enclosure, so as to take their polish and the impress of the striations upon them And, further, that portions may be thrust outside the apparatus in the form of protuberances of the nature of "eruptive cones." And thus it may be conceived that, by the force of high-pressure gas from below, rocks may be broken up and reconsolidated *in situ* to form breccias of diverse natures.

Some further applications of the experiments may be suggested.

Thus they may perhaps explain the origin of those remarkable natural pits of Hainaut, which have given rise to much discussion. In their general structure these pits are analogous to the diamond pipes of South Africa. Like them they are more or less circular perforations in the rocks, of unknown depth, and filled with rock debris. Since none of the explanations hitherto applied to them seem satisfactory, perforation by high pressure gas may be tried.

Again, in certain of the experiments the faces of the fissures in the cylinders of rock were found to be polished and striated. The polishing and striation of rock surfaces in connection with faults is known as slickensides, and ascribed to the movement of one surface over the other. M. Daubrée's results indicate the possibility that certain slickensided surfaces may rather be due to the energetic action of high pressure gas. In any case it is perhaps a little difficult to understand how a *single* movement of one rock surface over another—if we suppose a fault produced by a continued movement in one direction—could produce anything like a perfect polish. And it cannot be denied that the above experimental result shows the possibility of another cause.

And further, if we accept M. Daubrée's interpretation of his results, we arrive at the remarkable conclusion that gaseous bodies, given sufficiently high pressure and rapid motion, can polish and striate in a way generally supposed to be confined to solid bodies. This, indeed, is in conformity with the general results of advanced physical research which tends to show that, under sufficient pressure, hard and solid bodies can be made to act as liquids, while soft and even gaseous bodies, if endowed with sufficient force and speed, act like solids.

If, then, a gaseous body, under certain conditions of speed and pressure, can polish and striate a rock without the intervention of solid particles, is it not possible that ice, given certain conditions of speed and pressure, may likewise striate and polish without the graving tools usually considered necessary? The conception of an ice-sheet, or glacier, moving over the rock surface of the country with a series of pebbles and boulders firmly frozen into its lower surface is difficult to reconcile with the physics of ice masses in motion. Hence it seems worth while to make a trial application of the experimental results in this direction likewise. Even if we do not accept M. Daubrée's view that the striation of the rock surface was accomplished by the gas alone, and hold that the intervention of solid particles was required, there is still a possible application to glacial action. For if solid particles simply carried along by a rapidly-moving gas can produce parallel striations, may not particles simply carried along by the ice do likewise without being held firmly frozen into its mass? On either view, in fact, a difficulty in the conception of how a glacier striates and polishes is removed.

NOTES.

THE professors of the University of Melbourne have interviewed the Premier on the subject of the decrease in the grant to that institution. They said that there was no possibility of reducing the present staff, as it was not overmanned. Many of their number had come to the colony under special contract with the authorities of the university, and it would be a serious matter if faith were broken with them by insisting on a reduction in their salaries. Mr. Patterson replied that these were times of retrenchment, and it was right that everybody should contribute something to pull the country out of its difficulty. It appeared, however, that the University had been cut down £5000 last year, and it was further proposed to reduce the expenditure on the institution by £3000. He reiterated generally the statement made by the Minister of Education on the subject of retrenchment, but he promised to hold a consultation with Mr. Campbell, with the view of ascertaining if anything could be done in the matter. He thought it possible that Mr. Campbell, on taking a review of the special circumstances of their case, might see his way to some abatement of the rigorous course which had been proposed.

A MEETING of the Executive Committee of the Rothamsted Jubilee Fund was held on Monday, the Earl of Clarendon in the chair. On the motion of the Chairman, the Duke of Devonshire, as the incoming President of the Royal Agricultural Society of England, was added to the Committee. Sir John