THE Ramie, or China grass plant (*Bœhmeria nivea*), which has excited so much interest of late owing to its proposed extended cultivation in India, seems to thrive in Cayenne, specimens having been shown at a recent exhibition in that colony and compared with plants grown in France. The Cayenne plants, which were grown on a comparatively poor soil, without manure and with little or no attention, were double in size and height to those grown in France. Three successive shoots were produced in one year.

THE additions to the Zoological Society's Gardens during the past week include a Peguan Tree Shrew (*Tupaia peguana*) from Burmah, presented by the Hon. Ashley Eden, new to the collection; a Cinereous Sea Eagle (*Haliaëtus albicilla*) from Japan, presented by Capt. Sidney T. Bridgeford; two Bonnet Monkeys (*Macacus radiatus*) from India, presented by Sir F. S. Gooch, Bart.; a Sykes's Monkey (*Cercopithecus albogularis*) from Africa; a Robbin Island Snake (*Coronella phocarum*); a Horned Viper (*Vipera cornuta*), from S. Africa, deposited; four Four-spotted Opossums (*Didelphys opossum*) from South America, purchased.

*THE PAST AND FUTURE WORK OF GEOLOGY**

II.

"WE now come to the more special ground of the geologist. Starting with investigations connected with the origin of the globe, he has to trace the changes it has undergone through the various phases of its history, to determine the causes of those changes, and the manner in which they were effected. Besides dealing with inorganic matter, he has also to study the character and distribution of all organised things inhabiting the earth in all former periods, their order of succession, and the relation of the several and successive groups one to another."

Referring to the theories of the other geologists and to the philosophy of Hutton, Playfair, and their successors, Mr. Prestwich said it is a question whether the license which formerly was taken with energy is not now taken with time. Small forces long continued, action frequently repeated, and maintained uniformity of operation, are accepted as sufficient to account for the formation of our hills and plains, for the Alps and the Andes, and for all the great general as well as special features of the earth's crust.

The points at issue are, firstly, whether our experience on these questions is sufficient to enable us to reason from analogy; and secondly, whether all former changes of the earth's surface are to be explained by the agency of forces alike in *kind and degree* with those now in action. Mr. Prestwich then states his reasons for answering these questions in the negative :—

"The value of experience with respect to natural phenomena depends upon whether they are symmetrical and not variable, or whether they are variable and unsymmetrical. In the one case, as any one part bears a given uniform relation to the whole, if one part be known the whole can be inferred; but in the other case, where the whole is made up of unequal and not uniform parts, the value of the evidence is merely in proportion to the number of those parts independently determined, or to the ratio between the duration of the observation and the duration of the time comprising all the phases of the particular phemonenon. Thus the path of a planet, the date of an eclipse, or the return of a comet, may be predicted with certainty by the determination of mere minute sections of their orbits, which in respect to time are infinitely small compared to the length of the cycle of revolution. On the other hand, the metamorphosis of an insect, the mean temperature of a place, or the character of a volcano, can only be accurately determined by a length of observation sufficient to embrace all the variations they respectively present in their several cycles of change. In the case of the insect, the time must be equal to the duration of the metamorphosis; in that of temperature a succession of years is needed to obtain a mean; and with respect to volcanoes, centuries may often pass before we become acquainted with all the irregular exhibitions of their spasmodic activity.

"The necessity for a much greater extension of time becomes yet more imperative when we come to deal with geological phenomena, such as those due to the action of elevatory forces, which are extremely varied in their nature,—being at one time exhibited by a raised beach a few feet high, and at another by a mountain chain whose height is measured by miles; or by the small displacement produced by an earthquake, and the rectilinear fracture of a county with a displacement of thousands of feet.

"In taking into consideration the weight of the evidence where the series is so variable and irregular, it is clear that the increment of value is only in proportion to the increment of time. One phase of the insect life, one year's record of temperature, a century's observation of the volcano, give evidence which, although of value *pro tanto*, as one link in the chain, is entirely inconclusive when applied to the whole length. So in respect to such geological changes as those just named, the value of our experience is only in the proportion of the length thereof to the duration or cycle of the phenomenon under investigation. Thus the elevation of mountain ranges have been events of rare and distant occurrence. It has been estimated that all the great chains can be referred to thirteen epochs: taking subordinate ranges, the elevation of the main mountain chains of the old world may certainly be limited to twenty such periods. Divide geological time (since the sufficient consolidation of the crust of the earth) by this or even by double this number, and we may form some conception of the length of the cycles involving changes of this magnitude. What that time was it is impossible to say; we can only feel how infinitely it exceeded all our limited experience. With respect thereto the experience of five hundred years is no doubt of value—one or two thousand years add further to it;—but after all, how insignificant that duration of time is compared to the time over which the cycle extends; it may be as 1 : 100, or it may be as 1 : 200 or more, and I shall show presently that there are circumstances which indefinitely extend even these proportions. I conclude, therefore, that our experience in these cases is by far too limited to furnish us with reliable data, and that any attempt to reason solely from part to the whole must prove fallacious. Another argument adduced in support of this theory is, in my opinion, equally untenable.

"It is asserted that taking the degree of elevatory force now in operation, and allowing quantity of time, the repetition of the small changes on the surface witnessed by us would produce in time results of any known magnitude, *i.e.* that the force which could elevate a district 5 feet in a century would suffice in 100,000 years to raise it 5,000 feet. This reasoning might be conclusive if we had cause to suppose that the force were uniform and constant; but even our limited experience shows this to be irregular and paroxysmal, and although the effects indicate the nature of the force, they in no way give us a measure of its degree.

"Before I proceed further I must remove two objections which have been urged against what has been called the cataclysmic theory in opposition to the uniformitarian theory, both terms in themselves objectionable from their exaggeration, as all such terms usually are. One is, that we require forces other than those which we see in operation; and the other, that it is unnecessarily sought to do by violent means that which can be equally well effected by time. It is not, however, a question we raise as to the nature of the force, but as to its energy—it is not a question of necessity one way or the other, but of interpretation; it is a question of dynamics and not of time, and we cannot accept the introduction of time in explanation of problems the real difficulties of which are thereby more often passed over than solved. Time may and must be used as without limits; there is no reason why any attempt should be made either to extend or to curtail it; but while there is no need for frugality, there is no wisdom in prodigality. After all, it will be found that whichever theory is adopted, the need will not be very different; the mountain range, for the gradual elevation of which the one will ask 100,000 years, the other may require for its more sudden elevation a force taking the same number of years to accumulate its energies.

"We must, however, judge of the past by the features it has stamped on the land,* and these we must interpret not entirely by our own experience, not alone by our estimate of force, but by our knowledge of what amount of force the energy due to the thermal condition of the globe can develop on known dynami-

* Inaugural Lecture of J. Prestwich, F.R.S., Professor of Geology in the University of Oxford. Delivered January 29. Continued from p. 292.

* The evidence of facts with respect to the glacial period has already led to the admission of a greater intensity of cold; so we contend that the evidence of the past is equally definite respecting the greater intensity of energy

cal principles, and by our observation of what those forces have effected in past times.

"However we may differ in our interpretation of the present thermal state of the globe, most geologists agree in accepting the hypothesis of central heat as the one best in accordance with known facts relating to subterranean temperature, the eruption of igneous rocks, the action of metamorphism, and the crushing and contortions of rock masses. The radiation of heat into space has been accompanied by a gradual contraction of the central mass, and a shrinking of the crust, to which the trough of oceans, the elevation of continents, the protrusion of mountain chains, and the faulting of strata are to be attributed. The question is whether that contraction was accompanied by a like gradual yielding and adaptation of the solid crust to the lessening circumference of the globe; or whether the resistance of so rigid a body was only overcome by paroxysmal efforts. This latter was the view held by most of our early geologists, and is still the prevailing one abroad.

"It is not necessary to deal with the first steps of the problem. Let us take it after, for example, the readjustment of the crust, when it must have been many miles thick, which resulted in the elevation of such a mountain chain as that of the Alps; and here I must assume a point in advance. The resisting strata having given way to the tension to which they had been subjected, a state of equilibrium and repose would for a time ensue. As the secular refrigeration subsequently proceeded, the tangential force due to contraction resumed action, and while the larger areas were depressed chiefly by the action of gravity, other and smaller portions of the crust presenting the least resistance yielded, and rose at right angles to the tangential pressure.

"Now, either, if the elevatory force were limited and uniform in degree, a point would be reached at which that force was balanced by the increasing resistance and weight of the strata, and the movement would cease; or else, if the energy was a constantly generated quantity, and the rigidity such as to prevent yielding beyond a certain extent (and no solid crust can be perfectly flexible), then it would be a dynamical necessity that a time would come when, from the accumulation of that energy, it would overcome the resistance, and the opposing strata be suddenly rent and fractured. This primary resistance removed, the full power of the elevatory force would be brought to bear upon the disjointed mass, and the surplus energy expended in at once rapidly forcing forward and tilting up the now yielding strata, along the line of fracture, to that position and that height required to restore a state of equilibrium, and no more. It is not possible for any number of minor forces, where the ultimate resistance exceeds each one taken separately, to accomplish in any time, however long, that which requires for its execution a major force of infinitely greater power.

"Either a minor force, if sufficient to move a given weight, will go on moving, or else, if from any cause a further or secondary and independent resistance, such as, in this case, that dependent on the cohesion of the strata, has to be overcome, additional power must be brought to bear, which, if that secondary resistance be then overcome, the cumulated force being far in excess of the residual resistance, will be immediately expended with energy in proportion to the magnitude of the resistance mastered.

"Again, in the case of large faults traversing thick masses of strata, the conditions are nearly the same.

"The results of the foregoing conditions are in perfect accordance with observation. The enormous crumpling and folding of the strata—the vast upthrow of their disjointed edges—indicate the resistless forces which have been at work. Of these forces it is as difficult for us to realise the intensity as it is to fathom the immensity of space.

"While thus refrigeration progressed and the shell of the globe became thicker, other causes came into operation to give it greater rigidity, and so better fit it for the habitation of man.

"In the many discussions to which this question has given rise, it has been too much assumed that the shell was of uniform or nearly uniform thickness; the irregularities of the upper surface were apparent, but those possible on the under surface have been overlooked. I have, however, reason to suppose from some researches in which I have been engaged, that the under surface of the shell is ribbed and channelled in a manner and on a scale materially to influence the operation of that tidal action on which so many able and elaborate calculations have been based.

"Let us take on a continental area, having a mean surface temperature of 55° F., a point in the earth's crust through which any isotherm of depth passes,—suppose it to be that of 1,000°. This earth-isotherm will possibly be found about a depth of about 50,000 feet. The isothermal plane must approximatively follow the contours of the surface, and in mountain districts may rise some 1,000 to 4,000 feet above its other level."

Mr. Prestwich then shows that to the depth of the ocean we have to add a depth equivalent to the difference between the mean temperature of the adjacent land and that of the deep waters.

"As the position of the other earth-isotherms will in like manner occupy successive planes approximatively parallel with the surface whether of land or sea-bed, it follows that, if a central molten nucleus exists, it will be divided into areas separated by boundary lines, no less important than those formed by the continental areas between the several oceanic areas on the surface; and as they are even more enclosed and isolated, their condition with regard to the possible existence of tides would approach more to that of an inland sea such as the Mediterranean, where their influence is scarcely felt. It may be a question also whether the rigidity of the earth's crust is not influenced by this mode of structure. It must certainly affect the permanence of continental and oceanic areas.

"Notwithstanding this, it may naturally be asked in view of the more constant slow changes and movements to which, in past times, the crust of the earth has been subject, and that even up to a period so geologically recent as the elevation of the Alps and the Andes, how it happens that it is now so quiescent and comparatively immovable." Mr. Prestwich showed that the hypotheses both of Mr. Hopkins and Sir W. Thomson grapple with this difficulty, and in the same connection refers to the theories of Mr. Mallet. Mr. Prestwich is not, however, satisfied with the conditions suggested by these distinguished physicists, and is led to seek for other causes to account for the present stable condition of the earth.

"The cause which suggests itself to me," he said, "is the intense cold of the glacial period through which the earth has so recently passed, and which has, as it were, anticipated the refrigeration which, in ordinary course, would have taken a longer time to effect. At present the annual variation of temperature in these latitudes extends to a depth of about 30 feet; the maximum heat of summer being felt by the end of November, and the maximum cold of winter by the beginning of June at a depth of 26 feet. But supposing the cold of winter not to alternate with summer heat, then the abstraction of heat would continue to a depth in proportion to the length of time during which the cold at the surface was maintained and the degree of that cold, and such would be the effect over a large portion of the northern hemisphere (and I believe of the southern contemporaneously) during the glacial period. For as permanent ice and snow then extended down to these latitudes, the summer sun would not sensibly affect surfaces so covered, and the abstraction of heat must have proceeded uninterruptedly. To what depth the effect may have extended has not yet been investigated, but that it must have been very considerable is evident from the depth to which the annual variations are now felt. Consequently, with a uniform permanent temperature of 32°, or lower, at the surface, and with the long duration of the glacial period, we may form some conception of how far beneath the surface the extreme cold must have extended; even now, in parts of Siberia, the ground is permanently frozen to a depth of 300 to 400 feet. Then the surface temperature in these latitudes, instead of commencing as now with a mean of 50°, and attaining 70° at a depth of 1,000 feet, commenced with a temperature of 32° F. or less, and the isothermal of 70° must have been depressed far below its present level. On the return of the present more temperate climate, that portion of the crust of the earth, measuring certainly many hundreds, and possibly some thousands of feet in depth, which had suffered from this abnormal loss of heat, would have to recover its equilibrium with existing conditions by another change in the isothermal planes, and, until that was effected, little or no loss by radiation would take place.

"Or, to look at it in another way, let us suppose periods of equal temperature before and after the glacial epoch. As the radiation of heat is in proportion to the difference of temperature between the warm body and the surrounding medium, the loss of heat by the earth would, if no colder period had intervened, have been nearly equal in equal times; but with the greater cold of the glacial epoch, the same result would be effected in a shorter time; or, what is tantamount, the loss in the same time during the glacial period would be greater than in the other two periods. Thus, supposing we take any given time of the glacial period as

producing a refrigeration of the crust equal to that which would be effected in a certain longer time of the pre-glacial or post-glacial periods, then for a certain term of time—of length bearing some proportion to the difference between the two—succeeding the glacial epoch, the earth would, with its outer crust so much below the normal, lose little or no heat by radiation, so that during that subsequent period the thermo-dynamical effects due to cooling would be reduced to a minimum or cease altogether, and a period of nearly staple equilibrium, such as now prevails, obtain.

"This last great change in the long geological record is one of so exceptional a nature that, as I have observed elsewhere,* it deeply impresses me with the belief of great purpose and all-wise design, in staying that progressive refrigeration and contraction on which the movements of the crust of the earth depend and which has thus had imparted to it that rigidity and stability which now render it so fit and suitable for the habitation of civilised man; for, without that immobility, the slow and constantly recurring changes would, apart from the rarer and greater catastrophes, have rendered our rivers unnavigable, our harbours inaccessible, our edifices insecure, our springs ever-varying, and our climates ever-changing; and while some districts might have been gradually uplifted, other whole countries must have been gradually submerged; and against this inevitable destiny no human foresight could have prevailed."

SCIENTIFIC SERIALS

THE *Journal of Botany* for December 1874 and January and February 1875 contain quite the average of papers of general interest. Among the original papers may be mentioned in particular one on the critical species *Triticum pungens*, and another on *Rumex maximus*, by the Hon. J. Leicester Warren; descriptions of new species of Scilleæ and other Liliaceæ, by Mr. J. G. Baker; a list of the wild flora of Kew Gardens and pleasure-grounds, by G. Nicholson; *Anthoxanthum puelii*, by F. Townsend; and the continuation of the paper on the Botany of the Maltese Islands, by Mr. J. F. Duthie. A larger proportion of the space than usual is filled by reviews of botanical works, English and foreign. The plates include two of new species of *Ascobolus*, to illustrate a paper by Mr. James Renny; *Anthoxanthum puelii*, recently discovered in the south of England; and *Carex frigida* and *Salix Sadleri*, the two recent additions to the Scottish flora made by Mr. Sadler.

THE *Botanical Magazine* for February contains figures of the following plants:—*Epidendrum syringothyrsus*, a handsome species from Bolivia, with large racemes of purple-red flowers, tinged with lilac. *Lilium canadense*, var. *parvum*, a very handsome miniature lily, regarded by some as a distinct species. It has small orange-red flowers spotted with purple-brown. *Veronica pinguifolia*, a shrubby species from New Zealand, with very pale blue flowers. It is hardy at Kew. *Fourcroya Selloa*, an agave-like plant from Guatemala, whose large flower-scapes were allowed to protrude through the roof of the Succulent House at Kew last summer, and must have been noticed by many of our readers. *Senecio macroglossus*, the plant with ivy-like foliage alluded to in a recent number. Lastly, a new genus, *Erythrotis*, of Commelyneæ: an exceedingly pretty trailing plant from Malabar, having small leaves of a most brilliant crimson on the under surface, and small bright blue and red flowers. The species is called *Beddomei*, after Col. Beddome, its discoverer.

Zeitschrift der Oesterreichischen Gesellschaft für Meteorologie, Jan. 1.—On the curved tracks of cyclones issuing from the trade-wind region, by Dr. W. C. Wittner. Water resembles air in many of its movements, and is more easily observed; its eddies and currents especially may be studied with advantage in connection with cyclonic phenomena like the above-named. When a stream of water is met by another at right angles, a depression is formed at the point of interruption; particles bordering this depression sink into it in obedience to gravity, and particles at a greater distance move spirally inwards. Besides rotation there is a progressive motion of the whole eddy, in the direction of the resultant of the forces of the two streams. In turbulent streams eddies last a very short time; they are filled up almost as soon as formed. In quiet rivers, on the contrary, the whirl continues for a length of time sufficient for observation. In the development of hurricanes, difference of air-density corresponds to difference of level in water. Hurricanes, like eddies, are destroyed when the surrounding medium moves very irregularly, and we should therefore look to the neighbourhood of the tropics, where atmospheric conditions are remarkably regular, for a region favourable to their growth and progress. Near the northern boundary of the region of calms, the equatorial current begins at about S., and the polar meets it from about E., nearly at right angles, so that in this respect also the development of whirls, like those in water at the junction of rivers, is favoured. The resultant progression, towards N.W., becomes deflected as the storm advances, until, at a latitude where the eastward component of the equatorial may be supposed to vanish against the westward component of the polar wind, an excess seems to remain of the southerly over the northerly component, causing movement towards N. In still higher latitudes the more westerly equatorial and northerly polar drive the cyclone in an easterly direction. Occasionally, when the northerly component of the polar happens to be stronger than the southerly of the equatorial wind, as in the storm of Oct. 10, 1847, the system moves towards S.W. In the southern hemisphere, as in the northern, the direction of rotation indicates an irruption of the anti-trade into the trade-wind. The equatorial current, or anti-trade, appears to be the strongest both by its invasion of the trade-wind region and by the direction of advance of the consequent hurricane.—A communication from Captain Hoffmeyer, in the *Kleinere Mittheilungen*, contains valuable remarks on the relation between pressure and rainfall. In Denmark, most rain falls on the front of a minimum, and when a considerable depression is near. Like Mr. Ley, he believes that, at least in Europe, minima are formed simultaneously with heavy rains, but thinks that they are not caused by them, only magnified. He has come to the conclusion that minima must be looked upon not as results of mechanical rotation, but as functions of existing conditions and differences. They seem to him to seek and require continual nourishment. The principle of a descending current in maxima, and an ascending current in minima, broached by Mr. Buchan some years ago, he considers the only one with which we can overcome the difficulties presented by these phenomena. Air is interchanged mainly by vertical currents, resulting from thermal inequalities. Vapour also plays a large part in *ascending* currents. Low pressure at the earth's surface is not an indication but a cause of the *courant ascendant*. With these views, and by the comparison of weather charts, we can in general explain the main features of the atmospheric condition, though not indeed its ever-varying relations. Dr. Hann, in reply, maintains his opposition to the theory of Espy and Reye, that the *courant ascendant* is the sole or chief cause of a minimum in storms, and objects that the heaviest rains in the tropics do not in the least disturb the regular daily movement of the barometer, and to assume that the same cause in similar conditions could produce opposite effects would be illogical. Tropical rains have not been proved less extensive than those of higher latitudes, as some have supposed them to be. We have no clear evidence that condensation and rain diminish pressure. On the other hand, mechanics teach us that pressure must diminish towards the centre of a whirling mass of air. From these reasons, we should seek for an explanation in the laws of dynamics.

THE *Bulletin Mensuel de la Société d'Acclimatation de Paris* for October opens with a paper by M. S. Berthelot on "The Domestication of Animals," in which the writer expresses the opinion that the domestication of animals is due more to the art and skill of man than to their natural qualities; though the aptitude for domestication is unalterable in those animals which naturally possess it.—M. Bouillod contributes a paper on the cultivation of wild turkeys, recounting his experience in the matter, the object of which is not clear, seeing the domesticated turkey cannot be excelled in any respect.—Silkworm culture occupies its usual prominent position in the report.—The rapid growth of the *Eucalyptus globulus* is exemplified by M. Laberenne, who planted some seeds in Algeria on the 29th April, 1873, which twenty-six days later had already appeared above ground. In September, 1874, some of the plants had attained a height of 65 centimetres (26 in.).—M. Drouyn de Lhuys, in a speech on the Phylloxera, suggests that new plantations of vine from seeds should be formed, which he thinks would more easily repel the attacks of the pest.—Germany is making advances in the culture of the silkworm, which are detailed in a letter by M. A. Buvignier.

Astronomische Nachrichten, No. 2,020.—Mr. S. Burnham contributes a note on certain double stars. Σ 410 and H 334

* Philosophical Transactions for 1864, p. 305.