The fossils, generally speaking, have too wide a range to determine exact horizons in the Upper Greensand, but Mr. Jukes-Browne points out to me that *Cytherea plana*, which occurs as a phosphatic cast in the nodule-bed, favours the idea of erosion to below the Chert Beds, for he has not observed it from any higher horizon.

In the Memoir on the Isle of Purbeck (pp. 161, 162) I referred to the general consensus of opinion that there had been some slight erosion of the Upper Greensand before the deposition of the Chloritic Marl, and gave some instances, but I know of no other case in which the evidence is so strong or where the erosion appears to have been so great as at Mupe Bay. That it was strictly local is proved by the fact that in Lulworth Cove to the west, and in Warbarrow Bay to the east, the sequence is normal, and the Chloritic Marl resumes its normal thickness of 3 to 4 feet. It is unfortunate that the existence of a fault introduces a doubt how far the incompleteness of the sequence should be attributed to contemporaneous erosion and how far to subsequent movement. While accepting the evidence that there was erosion, perhaps considerable, of the Upper Greensand, I am disposed to call in the aid of the fault at the top as well as at the bottom of the cliff, to account for some of the missing beds.

My thanks are due to Mr. Hill for giving me the opportunity of making this correction, and for supplying much of the material on which it is founded.

NOTICES OF MEMOIRS.

I.—Origin of the Ancient Crystalline Rocks.—Dr. Frank Dawson Adams gives an account of the excursion to the Pyrenees in connection with the Eighth International Geological Congress (Journ. Geol., 1901, ix, pp. 28–46). The object of the excursionists was to examine, under the leadership of Professor Lacroix, certain intrusive granite masses, which have not only intensely altered the strata through which they pierce but which have produced a wholesale transformation of the sedimentary rocks in question into granite, the granite now occupying the space formerly occupied by the sediments. The districts examined were Aix-les-thermes, L'Etang de l'Estagnet, L'Etang de Baxouillade, Cirque de Camp Ras, Foix, Arignac, Cabre, Vicdessos, Sem, Massat, Bagnères-de-Bigorre, Pouzac, Payole, Cirque d'Arbisson, and Barèges. While recognizing that the excursion was merely a rapid traverse of a district which has received detailed attention from the French petrographers, Dr. Adams sums up as follows: "While the transfusion of a certain amount of material into the limestones along the immediate contact of the intrusions and also a solution of the limestone to a limited extent in certain cases seems highly probable; the wholesale transformation of limestone into diorite, or of shale into gneiss and granite, which has been described in the case of these contact zones of the Pyrenees, is as yet very far indeed from being proved."

II.—Nodular Granite from Pine Lake, Ontario. By Frank Dawson Adams, Ph.D. (Bulletin of the Geological Society of America, 1897, vol. ix, pp. 163–172, pl. xi; February 10, 1898.)—Professor Adams, while carrying out some work for the Geological Survey of Canada in the eastern part of the Province of Ontario, has discovered a remarkable occurrence of orbicular or nodular granite in the township of Cardiff, in the county of Peterborough. In this part of the country the fundamental rocks are Crystalline Limestones, associated with Gneisses and Amphibolites, broken through by great intrusions of Granite. The nodule-bearing Granite occurs on the north and south sides of Pine Lake. It is rather fine-grained and usually gneissic in places, but often massive. The nodules are confined to a portion only of the Granite, and are not in proximity to the Amphibolite; and therefore the nodular structure is not a contact phenomenon. The nodules are spherical or ellipsoidal, and occur either scattered through the rock or, more rarely, in lines. When the nodules occur in rows they gradually get closer together until they seem to fuse or coalesce into a continuous band or vein. The centres of the nodules exhibit little segregation bunches of schorl. Professor Adams concludes that these nodules are due to a primary differentiation of the magma, for the reason that they do not include certain minerals such as Microcline, which have evidently crystallized from the magma latest, and which are abundant in the surrounding Granite; while on the other hand Sillimanite occurs in the nodules, being one of the first to separate from the magma, but does not occur in the surrounding Granite.—F. C.

III.—An Experimental Investigation into the Flow of Marble. (Philosophical Transactions of the Royal Society of London, 1901, vol. cxcv, pp. 363–401.)—These experiments have been carried out by Messrs. Frank Dawson Adams and John Thomas Nicolson; pure Carrara marble being the rock selected. The paper deals with the methods employed, deformation of the dry rock at ordinary temperature, at 300 C., and at 400 C., and at 300 C. in the presence of water. Comparison is made of the structures produced in Carrara marble by artificial deformation with those produced by deformation in the case of metals, and comparison of the structures produced with those observed in the limestones and marbles of highly contorted portions of the earth's crust. The following is the summary of results:—(1) By submitting limestone or marble to differential pressures exceeding the elastic limit of the rock and under the conditions described by the authors, permanent deformation can be produced. (2) This deformation, when carried out at ordinary temperatures, is due in part to a cataclastic structure and in part to twinning and gliding movements in the individual crystals composing the rock. (3) Both of these structures are seen in contorted limestones and marbles in nature. (4) When the deformation is carried out at 300 C. or, better, at 400 C., the cataclastic structure is not developed, and the whole movement is due to changes in the shape of the component calcite crystals, by twinning and gliding. (5) This latter movement is identical with that produced in metals

by squeezing or hammering, a movement which in metals as a general rule, as in marble, is facilitated by increase of temperature. (6) There is therefore a flow of marble just as there is a flow of metals under suitable conditions of pressure. (7) The movement is also identical with that seen in glacial ice, although in the latter case the movement may not be entirely of this character. (8) In these experiments the presence of water was not observed to exert any influence. (9) It is believed, from the results of other experiments now being carried out but not yet completed, that similar movements can, to a certain extent at least, be induced in granite and other harder crystalline rocks, and that several structures developed in these rocks in nature in highly contorted regions can thus be reproduced. Photo-micrographs of the marble are given.

IV.—Geology of West Cornwall.—Mr. J. B. Hill, who has been studying the geological structures of Western Cornwall for some years, has been talking to the Royal Geological Society of Cornwall about them. His paper has appeared in the Transactions (1901, vol. xii, pt. 6), and his conclusions, given in his own words, are as follows:—"The structures of the stratified formations in West Cornwall are identical with the structures of crystalline schists. In the Falmouth district, so far as yet examined, true slates have not been met with. The strata have been thrown into a series of isoclinal folds, accompanied by small faults. With these folds and faults minor structures have been set up until the whole rock has often become a mass of minute folds and thrusts, with their accompanying strain-slip cleavages. These processes have been carried so far that 'crush-conglomerates' have been produced on a large scale. It is evident, from a study of this district, that had the rocks been subjected to those stresses at a greater depth and below the zone of fracture, where they would not have been so free to move, they would have been converted into true schists. They possess now every structure of schists, but the mineralization has been wanting."

"The visible dip of the rocks is of no value, except as registering the inclination of the limbs of folds. As an illustration of this fact, it may be pointed out that although the strata have a general dip to the south-east, between Falmouth and Truro, we are apparently crossing the strike from the coast to the heart of the county, yet, instead of getting deeper in the stratigraphical series, we are on precisely the same geological horizon as at Falmouth, the intervening ground being made up of a succession of isoclinal folds."

This last paragraph is, we believe, confirmatory of De la Beche's view, and does not support the view sometimes expressed, that in this district we have a great thickness of sedimentary deposits.

V.—Argonaut from the Tertiary of Japan.—Mr. Yoshiwara has just published in *Annotationes Zoologicæ Japanenses* (1901, vol. iii, pp. 174–176) a description of a supposed new Argonaut from the Neogene tuff of Agenokimura, near Matsue, Iugori, province Izumo, Japan. This was found by Mr. J. Asāi, and mentioned by Professor

Jimbo as long ago as 1896 in the *Journal of the Tōkyō Geographical Society*, vol. viii. The specimens, of which there are two, can only be distinguished from '*A. tuberculosa*, Linn.' (said by Yoshiwara to be identical with *A. nodosa*, Sol., and *A. oryzata*, Mensh.), by the general outline of the shell, the size of the whorls near the centre, and the rows and numbers of the ribs. It is of considerable interest to find that this tuberculate form of the genus, which has never been found living in Japan, existed there in Tertiary times.

VI.—The Grand Canyon of the Colorado.—Professor W. M. Davis has published in the Bulletin of the Museum of Comparative Zoology at Harvard College (Geol. Series, v, No. 4, May, 1901) an account of an excursion to the Grand Canyon of the Colorado. His results may be summarized as follows:—"There is some probability that the San Rafael swell, like the Waterpocket flexure, is of pre-Tertiary origin. The other deformations of the region, both flexures and faults, are almost exclusively of much earlier date than the canyon cycle, and they may have been formed relatively early in the erosional history of the district. The total denudation of the region thus far accomplished may be considered in two parts, of which the first—the great denudation—was far advanced before the general uplift by which the second—the erosion of the canyon and the stripping of weak strata from the plateaus—was introduced."

"But the great denudation was complicated by repeated movements, after each of which the processes of erosion may have reached an advanced stage before the occurrence of the next series of disturbances. It is only by an analysis of these repeated movements and revived erosions that the origin of the drainage system can be determined. As far as this analysis can be attempted at present for the Grand Canyon district, the side streams seem to be of various origins, except that none of them appear to be antecedent. The Colorado itself may be in part antecedent to some of the many dislocations that the district has suffered, but it seems to be for the most part consequent on the displacements caused by faulting in the later part of the great denudation, and on the form that the surface had assumed at that time."

"The floor of the Toroweap valley is higher than the neighbouring valley floors, because it is sheeted with heavy lava flows which have effectively withstood the intermittent erosive effects of wet-weather floods. The past climate of the region cannot be safely determined; a change from a humid to an arid climate at the close of the Miocene does not appear to be demanded by the facts that have been appealed to in its support."

Professor Davis gives a bibliography and some illustrations, many of which are new, and one of which, a general photographic view of the Grand Canyon, is especially good. T. R. J.

VII.—Shorter Geological Notes.—Elkanah Billings, for twenty years palæontologist to the Geological Survey of Canada, and the founder of the *Canadian Naturalist and Geologist*, formed the subject of Dr. Ami's address as president of the Ottawa Field

Naturalists' Club,' last December. The material has now been extended, a bibliography added, and the whole published in the *American Geologist* for May.

Professor E. W. Hilgard's "Historical Outline of the Geological and Agricultural Survey of the State of Mississippi," which appeared in the publications of the Mississippi Historical Society, has been reprinted in the *American Geologist* for May. It gives an interesting picture of the origin, rise, and progress of one of the United States Surveys, and provides an official account of the publications, always of value.

Mr. J. A. Cunningham has published a contribution to the Theory of the Order of Crystallization of Minerals in Igneous Rocks, in the Scientific Proceedings of the Royal Dublin Society (1901, vol. ix, pt. 4). The paper should be read in connection with Dr. Joly's paper, "Theory of the Order of Formation of Silicates in Igneous Rocks," published by the same Society in 1900.

REVIEWS.

I.—The Mineralogy of Scotland. By the late M. Forster Heddle, M.D., F.R.S.E. Edited by J. G. Goodchild, F.G.S. 2 vols.: 360 pp., 30 figures in text, 117 plates. (Edinburgh: David Douglas, 1901. Price 36*s.* nett.)

DURING the greater part of a long life the late Professor Heddle, for many years Professor of Chemistry in the University of St. Andrews, spent his holidays in the mineralogical exploration of his native country, and scarcely a single locality from which there was a likelihood of obtaining good specimens can have been left unvisited by him; he was thus able to bring together a collection of Scottish minerals remarkable for its completeness and for the excellence of its material; to its examination, chiefly chemical, he devoted all his available time. Some years ago the collection was purchased for the nation and deposited in the Museum of Science and Art at Edinburgh; there it was arranged and labelled, for public exhibition, by Dr. Heddle during the latter years of his life.

Of the topographical and chemical mineralogy of Scotland, Professor Heddle had thus an unsurpassed knowledge, and he made voluminous notes with a view to the eventual publication of a treatise by means of which the information so laboriously acquired might be preserved to posterity. Unfortunately, like too many other investigators, he was called to his rest when his work was still far from complete; there was thus a great danger that his notes might never be printed and made available for general use. His family has done what was possible to avert the threatened catastrophe, and have obtained help for the completion and editing of the work; the notes have been prepared for press and the treatise has been edited by Mr. J. G. Goodchild, who is now closely associated with the custody of the collection itself.

To complete the work, Mr. Alexander Thoms, son-in-law of