

suitable screens between the source of light and the object to be illuminated; but it appears doubtful whether enough light can be easily obtained in this way for very high magnifications.

With regard to the selection of the specimens to be examined, it is well known that much time is wasted when working out a complete series of alloys of two metals. It is necessary to prepare, polish and etch a series of specimens, many of which will present no features of interest when examined under the microscope. M. Le Chatelier proposes to shorten the search for typical alloys by melting together two superimposed layers, each consisting of a pure metal, the lighter one being on the top. If no alloys are formed of greater density than the heavier metal, and the crucible is allowed to cool undisturbed, a culot can be obtained which, on being sawn through vertically, shows a complete gradation from one pure metal to the other, passing through the whole series of alloys, which can then be studied in one specimen. In this way he prepared a number of series, the three illustrations (Figs. 1, 2 and 3) being from



FIG. 3.—Crystals of  $\text{AlCu}_3$ .

photographs of different parts of a single specimen showing the aluminium-copper series. Fig. 1 shows crystals of  $\text{Al}_2\text{Cu}$ ; Fig. 2, crystals of a compound of undetermined composition which is not far from that expressed by the formula  $\text{AlCu}$ ; Fig. 3 shows crystals of the compound  $\text{AlCu}_3$ . It would seem that the exact percentage of any particular part of a specimen prepared in this way must be a matter of uncertainty, but there is no doubt that, in the hands of M. Le Chatelier, the method has already yielded some interesting results.

T. K. ROSE.

#### SOME RECENT ADVANCES IN GENERAL GEOLOGY.

AMONG the recent researches on organic remains none are of greater geological interest and importance than those relating to the Radiolaria. The tiny siliceous structures which belong to this Order of Protozoa have long been recognised in our formations, but the part they have played in building up portions of the stony structure of the earth has not until lately

been realised. The most striking evidence was that brought forward by Prof. Edgeworth David and Mr. E. F. Pittman (*Quart. Journ. Geol. Soc.*, vol. lv. p. 16, 1899). They describe a great series of siliceous limestones, jaspers and claystones, with interstratified coral limestones and plant-beds, and submarine tuffs, the whole attaining a thickness of over 9000 feet, and extending over many hundred square miles in New South Wales. In the bulk of these rocks Radiolaria are present at the rate of about one million to the cubic inch, and among the forms Dr. G. J. Hinde has recognised twenty-nine genera and fifty-three species. Taken as a whole, the deposits are fine-grained, and bear evidence of having been laid down in clear seawater, beyond reach of any but the finest sediment. They do not indicate any very considerable depth of water; but they tell of a vast lapse of time, and of conditions which prevented the dispersal over the area of coarse detritus. What exactly were these conditions it remains for future research to discover. In this country, in Devonshire and Cornwall, the occurrence of radiolarian cherts, both of Ordovician and Carboniferous ages, has been made known through the observations of Dr. Hinde, Mr. Howard Fox and Mr. Teall. The more prominent of these rocks are found in the Lower Carboniferous formation of Coddon Hill near Barnstaple, where the chert-beds have long been known, although their organic origin was not until recently discovered. The freedom of the beds from mechanically-formed detritus has led to the supposition that these strata were deposited in deep water and at some distance from the coast, although the associated strata above and below the chert-beds do not lend support to the hypothesis. The fact is that at the present time the only extensive radiolarian deposits known to be in process of accumulation are in the deeper oceanic regions.

Radiolaria, while entirely marine, are widely distributed, and they can exist at various depths in deep and shallow seas. It may be surmised, therefore, that in shallower areas coral-reefs may have acted as barriers to the dispersal of terrestrial *débris*. Hence in our explanations of the physical conditions of the past we must be guided by the general characters of the sedimentary strata in which bands and beds of radiolarian chert occur, rather than by the evidence of the chert itself. There is, however, little doubt, from the wide distribution of these lowly forms of life, that they may prove of considerable importance in the identification of horizons, although, as might be expected from their present geographical and bathymetrical ranges, some specific types have been of long geological duration.

In the coast ranges in California, and again in Borneo, such radiolarian rocks of Jurassic, or possibly Lower Cretaceous age occur, and it is noteworthy that Dr. Rüst has remarked that "the differences in the Radiolaria from these two rock-divisions are not very striking." (See Hinde's "Description of Fossil Radiolaria from Central Borneo," 1899.)

The question whether the Wealden strata which are essentially freshwater should be grouped as Jurassic rather than Cretaceous has been raised by geologists in the New as well as in the Old World, who have argued that the Wealden plants, fishes and reptiles are Jurassic rather than Cretaceous in character. There has never been any question in this country that the Purbeck and Wealden Beds are intimately connected both stratigraphically and palæontologically, and it has been held by some geologists that locally the Wealden Beds and Lower Greensand bear also evidence of continuous deposition. The subject was lately discussed by Mr. G. W. Lamplugh (*Brit. Assoc., Bradford, 1900*), who points out that in Dorset, Hampshire and Surrey there is evidence of the close stratigraphical connection between Wealden and Lower Greensand, that part of the

freshwater Wealden must represent true marine Lower Cretaceous beds elsewhere, and that consequently it is equally erroneous to classify the Wealden series entirely with the Jurassic system or entirely with the Cretaceous.

If the planes of division between our formations are more often than not ill-defined, so also are those between the main systems. Between our Palæozoic and Mesozoic strata there has never been a very well-marked boundary, for some authorities have placed the Permian with the older division and some with the newer.

The tendency of recent investigations in the midland areas is to show that a considerable series of red beds which have been regarded as Permian are truly portions of the Coal-measures, while it is evident that the Magnesian Limestone series is stratigraphically united more closely with the Triassic strata. In Britain the main mass of the Permian (Magnesian Limestone series, &c.) lies unquestionably with great discordance on various subdivisions of the denuded Carboniferous and Devonian rocks. Abroad in many areas, in India, Australia and elsewhere, there appear connecting links in strata grouped as Permo-Carboniferous; but it is a question whether the original Permian is anything more than a provincial set of strata, unentitled to rank with a system (see C. R. Keyes, *Journ. Geol.*, Chicago, vol. vii. p. 337, 1899).

As the history of the successive strata in different countries becomes better understood, so it becomes possible more closely to parallel the life-epochs which are represented in the rocks. Such life-epochs do not of course correspond with the sedimentary changes which are recorded by the rocks themselves, and hence a double system of grouping becomes needful. In our own country this has been long apparent, and the successive groups of strata which are so well established in the Ordovician and Silurian systems of Wales, the Lake District and the Southern Uplands of Scotland require distinct stratigraphical terms, while the life-history and the correlation of the subdivisions are indicated by the zonal groupings based on zoological evidence. The representation on maps and in sections of the main stratigraphical groups, or geological formations, is essential in order to show the physical structure of a country, not only in reference to economic questions, but also in regard to the influence on the present scenery of the rocks and the movements to which they have been subjected. Different types of landscape and the evolution of river systems are engaging a good deal of attention, notably in the United States; and the study has led to the introduction of a large number of terms which are rather difficult to remember, but the more important are explained in Mr. J. E. Marr's "Scientific Study of Scenery."

Increasing attention is given to the great movements which have affected the rocks especially in mountain regions. The pioneering work of Heim in Alpine regions has been utilised and developed in the most brilliant manner by Lapworth and Rothpletz and many others. The old ideas of reversed faults have been, so to speak, magnified into great earth movements, whereby huge masses of country have been overfolded, fractured, and overthrust, the older being pushed over the newer. On a small scale such overthrusts were long ago recognised in some coal-fields by the name of overlap faults, and the displacement was measured by yards—now it is sometimes reckoned by miles. Moreover, not only in Highland regions where the secret inferred by Nicol was unravelled by Lapworth have these mighty overthrusts been made manifest, but on a comparatively small but by no means unimportant scale they have been traced out and pictured in the Cretaceous rocks of the Isle of Purbeck by Mr. A. Strahan. The same observer has drawn attention to other overthrusts in the great Coal-field of South Wales.

All sorts of complicated structures due to cross-folding

and faulting, to successive horizontal displacements and twisting, have been produced in mountain regions; and Dr. Ogilvie Gordon has dealt exhaustively with the subject in a paper on the torsion-structure of the Dolomites (*Quart. Journ. Geol. Soc.*, vol. lv. p. 560). To quote one sentence from her paper will, perhaps, be enough to give an idea of the puzzles she has attempted to solve: "Anticlines have been twisted round synclines, and the rocks in the synclines have themselves been twisted and distorted, buckled up and depressed, overthrust and faulted normally, cross-faulted and cleaved, to an extent that has not hitherto been realised." We may add that the subject of torsion-structure has been examined mathematically by Mr. J. Buchanan (*Phil. Mag.*, vol. i. p. 261).

The evidence of great folds and flexures, accompanied by overthrust faults, has lately been brought more fully to light in the Malvern region by Prof. T. T. Groom, while in the Lake District the field labours of Mr. J. E. Marr and Mr. A. Harker, as recently expounded (*Proc. Geol. Assoc.*, vol. xvi. August 1900), indicate that the country has there been affected, not only by overthrust faulting, but by more or less horizontal displacement, termed "lag" faults, whereby lower and older strata have been moved more rapidly than newer overlying strata, which consequently have lagged behind. Other faults, called "tears," are described, where, during these movements, rents have occurred in the shifting masses of strata without occasioning much vertical displacement.

In very many cases along fault-planes there has been produced a kind of breccia due to the effects of displacement, but more striking results of such action have lately been made known in the production of conglomerates. In such cases the effects of earth-movements have not only fractured, but actually worn away, the edges of the shattered rocks. In the Isle of Man, where the Manx slates have undergone acute folding followed by intense shearing, the shear-cleavage has cut and displaced bands of grit and has actually rounded the fragments so as to produce what Mr. Lamplugh has termed a crush-conglomerate. His observations have borne good fruit elsewhere. Mr. C. A. Matley has described crush-breccias and crush-conglomerates in Anglesey, where they occur "along zones of powerful crushing, especially in areas where the soft, fine-grained, slaty rocks alternate with tougher and more brittle strata, such as grits and quartzites" (*Quart. Journ. Geol. Soc.*, vol. lv. p. 657), and Prof. Groom has dealt with the crush-breccias of the Malvern Range (*ibid.*, p. 151).

It has long been felt that some revolution in palæontological nomenclature is needed, and, fortunately, the matter has been taken up boldly and effectively by Dr. Arthur W. Rowe.<sup>1</sup> In old times new species were named from fossils obtained from formations without reference to their special horizons. Some were founded on the evidence of but one or two specimens, and it has not unfrequently happened that "varieties" have been found which preceded in time the type species. Of late years, when increasing attention has been given to careful collecting, there has been a tendency to "make every prominent form a species, on the plea that every minute variation must be ticketed and pigeon-holed." In this way very many of the old land-marks have been removed, the study and identification of species have passed beyond the comprehension of any but the specialist, and the value of his labours to others has been more and more reduced or obscured. Dr. Rowe has now for some years devoted the leisure of a busy life to a careful collection of *Micrasters* from successive stages or zones in the Middle and Upper Chalk. He finds that by examining the facies of the genus in each horizon, passage-forms prove to be the rule, while sharply-defined and typical species are the exception. He has been able to trace an unbroken continuity in

<sup>1</sup> *Quart. Journ. Geol. Soc.*, vol. lv. p. 494.



the evolution of *Micraster*, so that in successive stages of the Chalk he finds variations in the structure of the tests, variations indeed which "are so marked that one can tell by their aid from what zone a *Micraster* is derived." As passage-forms and mutations form the bulk of the genus, it is necessary to mass certain obviously allied forms into groups which will admit of the zoological continuity being exemplified and the zonal peculiarities noted. This is the plan adopted by Dr. Rowe, and it certainly appears most philosophical to take a series of specimens rather than an individual as the foundation for a zonal specific type; and to group rather than to try and separate so many forms. It is satisfactory to learn that the detailed zoological work carried out by Dr. Rowe bears witness to the great value of the palæontological zones which were broadly marked out in the chalk of this country nearly twenty-five years ago by Dr. Charles Barrois.

There is no doubt that the careful collecting of fossils from definite horizons, and from horizons in definite sequence, is of the utmost importance in advancing palæontological knowledge. Such work, as a rule, requires prolonged labour, otherwise the conclusions are worse than useless. Now, by close research, it is possible to trace out the successive modifications that occur in stratigraphic sequence, and this has been attempted with the Graptolites, and with several groups of Mollusca and Brachiopoda, as well as with Echinodermata. Even in so variable a group as the Oysters, it is affirmed by Messrs. R. T. Hill and T. W. Vaughan (*Bulletin U.S. Geol. Survey*, No. 151) that these organic remains possess very distinct specific characters, have definite geologic horizons and are of the greatest value in stratigraphic work. Their value, moreover, may be not merely scientific, but also of some benefit to humanity. Instances have occurred in Texas where, by the aid of these fossils, brought up from great depths in diamond-drill cores, cities upon the point of abandoning the attempt to procure artesian water have been warranted in drilling a few feet farther, and with success.

Views on the duration of geological time have occupied a considerable amount of letterpress during the past fifty years, and during the past few years the subject has been discussed by Mr. G. K. Gilbert, Mr. J. G. Goodchild, Sir A. Geikie, Prof. J. Joly, and Prof. W. J. Sollas.

Mr. Gilbert would look to the influence of precessional changes and to the periodic modification of the climatic conditions of the two hemispheres. Contrasted phases of climate would thus occur every 10,500 years, and such changes should be looked for in the strata. Indications of moist or dry climates, of the increase or decrease of glaciers, and of the local fluctuations of sea-level as affecting the character and extent of strata are the indices to which he would appeal.

Prof. Joly, arguing from the amount of sodium at present contained in the waters of the ocean and the amount annually supplied by rivers, claims that a period of between eighty and ninety millions of years has elapsed since the land first became exposed to denuding agencies. Sodium, as stated by Prof. Joly, is the only dissolved substance of which the ocean has retained substantially the whole amount committed to it by the solvent denudation of geological time.

Prof. Eug. Dubois, dealing with the circulation of carbonate of lime, believes that the real lapse of time since the formation of a solid crust and the appearance of life upon the globe may be more than one thousand million years.

Mr. J. G. Goodchild in 1897 also argued that the more trustworthy data relating to the time of formation of marine strata were furnished by deposits of organico-chemical origin. He concluded that over seven hundred

million years would be required since the commencement of the Cambrian period.

Although the conclusions arrived at by investigators are widely at variance, it is not improbable that some trustworthy data may in time be gained by the different methods of research advocated by Gilbert and by Joly. As lately remarked by Sir A. Geikie, progress in geology will be best made by the adoption of more precise methods of research and by a hearty co-operation among geologists in all parts of the world; and Prof. Sollas well observed in his address at Bradford that "our science has become evolutionary, and in the transformation has grown more comprehensive." The work of the palæontologist must be supported by very detailed local field-work, work which at present is very much in its infancy. Such work will help in the grand story of "the science of the earth," a story whose materials can only be gathered together by the patient local toiler; while he or she may well be content to see the results worked up by those who by training and opportunity are able to take a comprehensive view of the earth as a whole.

H. B. W.

#### LORD ARMSTRONG, F.R.S.

THE death of Lord Armstrong on Thursday last, in his ninety-first year, will be regretted in the world of engineering and applied science. To the general public he was best known as a manufacturer of munitions of war, but engineers will remember him more for his developments of hydraulic machinery, and in science his name will be associated with the discussion of the duration of our coal fields, and the development, and discharge phenomena, of statical electricity.

William George Armstrong was born at Newcastle-upon-Tyne in 1810, and educated at a school at Bishop Auckland. He adopted the law as a profession, and became a partner in a firm of solicitors; but a strong bent for scientific pursuits led him to study mechanics with more interest than law and eventually diverted him into another career. Early in life he began investigations of electrical subjects, which resulted in the invention of the hydro-electric machine familiar to all readers of text-books of electricity. The circumstances which suggested this novel electrical machine are well known. The workmen at a colliery near Newcastle had observed that when steam was blowing off from the high-pressure boiler, a smart shock was received if the safety valve was touched, and sparks could be seen. An investigation of the phenomena showed Mr. Armstrong that the boiler was insulated on a dry seating, and the friction of the water particles against the sides of the orifice through which it was escaping caused a development of electricity. On this discovery he based the construction of his hydro-electric machine, which at that time formed the most powerful means of generating frictional electricity. It consisted essentially of an insulated boiler, from which steam at high pressure was allowed to escape through nozzles of peculiar construction. For this he was elected a Fellow of the Royal Society in 1846, while still comparatively a young man.

Another electrical research for which Lord Armstrong will be remembered was concerned with electric movement in air and water, and it culminated in the publication of an elaborate volume on the subject in 1897. In this work a striking experiment, performed with the hydro-electric machine half a century earlier, was made the starting-point of a valuable research on the nature of electric discharges. Two glasses of distilled water were placed near together, and a thread of cotton, which was coiled up in the one, had its free end placed so as to dip in the other. On negatively electrifying the glass of