Some Aspects of Modern Geology Discussed.

IN the Geology Section of the recent Jubilee Session of the Indian Science Congress presided over by the eminent Indian geologist Mr. D. N. Wadia of the Geological Survey of India, many important papers were read and valuable discussions held, dealing with several aspects of modern geology. There was a large and representative gathering of geologists including Professors of Geology from almost all the Indian Universities, and Officers of the Geological Surveys in various parts of India. There were also present some of the foremost geologists from abroad, as part of the foreign delegation, such as Prof. P. G. H. Boswell, O.B.E., D.Sc., F.R.S., Professor of Geology, Imperial College of Science and Technology, London, Dr. A. L. du Toit, D.Sc., F.G.S., Consulting Geologist of Johannesburg, S. Africa. Prof. W. G. Fearnsides, F.R.S., Prof. of Geology in the University of Sheffield, Sir L. L. Fermor, O.B.E., D.Sc., F.R.S., Former Director of the Geological Survey of India, Prof. W. T. Gordon, D.Sc., Professor of Geology in the King's College, London, Prof. F. K. Morris, Ph.D., Professor of Geology, Massachusetts Institute of Technology, Mass., U.S.A., and Prof. H. H. Read, D.Sc., Prof. of Geology in the University of Liverpool. The visiting geologists took a keen interest in the papers presented, and participated freely in the discussions, thus contributing to make the proceedings lively, useful and stimulating. The following is a brief account of some of the discussions and symposia held during the session.

Chronological Testimony of Fossil Plants and Animals.

Under the joint auspices of the sections of Geology and Botany, a symposium on "Discrepancies between the chronological testimony of fossil plants and animals" was held on Tuesday, 4th January 1938. Dr. A. L. du Toit, the well-known geologist of S. Africa, presided.

Prof. B. Sahni (Lucknow) in opening the discussion referred to the increasingly important part played by fossil plants in the age determination of strata, and said that the apparent discrepancies between the chronological testimony of fossil plants and animals were mostly of our own creation—due to such factors as incorrect identification of fossils, the absence of sufficiently detailed and accurate observations in the field, etc. In all cases where stratigraphical position of a bed has been accurately noted in the field, and where the fossil plants and animals collected from that particular horizon have been investigated correctly, no discrepancy is ever noticed between their chronological testimony. In support of his conclusions, Prof. Sahni referred to a number of cases in Indian stratigraphy where there was supposed to be a discrepancy between the chronological testimony of fossil plants and animals, and after examining in detail the evidence in each case, showed how recent and more definite studies of the fossils and their exact position in the bed from which they have come, have made it clear that there is really no discrepancy of any kind. In fact it is not likely that a real discrepancy can ever exist between the chronological testimony of fossil plants and animals.

Mr. D. N. Wadia (Calcutta) referred to four instances in India where there appeared to be a discrepancy in the testimony of fossil plants and animals—(1) the Po series of Spiti Himalayas, (2) the agglomeratic slate series of Kashmir, (3) the Gondwanas of the East Coast, and (4) the Deccan inter-trappean beds. Of these, he said, that except in the case of (3), the discrepancies were of minor significance, and can probably be accounted for as due to varying conditions of sedimentation, bad preservation, etc. In some cases, a real discrepancy may arise due to a lag in the rate of evolution of plants and animals in widely separated areas. He was of opinion that stratigraphic data carefully collected in the field, should be given prime importance in dealing with all such cases of discrepant testimony.

Dr. M. R. Sahni (Calcutta) supported the view that there are no real discrepancies between the evidence of the plant and animal fossils. Detailed work has shown that the apparent discrepancies are merely due to such factors as (*a*) imperfection of the geological record, (*b*) misinterpretation of this record because of insufficient data, (*c*) incorrect determination of fossils, (*d*) conclusions drawn from purely geological evidence in the absence of fossils, and (*e*) even inadvertent mixing of fossil-collections, from different horizons. He amplified and substantiated these points with reference to three important formations in India where such discrepancies are supposed to exist: (i) the Deccan trap, (ii) the Gondwana rocks, and (iii) the Po series; and showed that the alleged discrepancy in each case may be explained, as due to one or the other of the above factors. Dealing with the question—do faunas and floras evolve at different rates?—Dr. Sahni was of the opinion that to suggest that marine animals evolved more rapidly than plants owing to differences in environment and organic structure, and so gave rise to discrepancies was not altogether justified by facts.

Dr. A. L. du Toit (S. Africa) in concluding the proceedings, pointed out that the apparent discrepancies in the dating of formations by means of their respective marine and terrestrial fossils can be ascribed to a number of factors such as, for instance, (1) the uncertainties pertaining to the geological system—boundaries either locally or regionally, whereby correlation-errors are introduced, (2) evolutionary changes during migration along extended paths whereby widely parted faunas could become 'homotaxial' instead of synchronous, correspondences in stratal succession not necessarily implying contemporaneity in deposition, and (3) climatic, oceanographic, orogenic and other influences that have affected in different degrees or senses the life of the seas and lands, and impressed themselves differently on the marine and terrestrial biota. He particularly stressed on another vital factor, *viz.*, continental drift. He pointed out how there was probably a creeping of the condensed land masses of Laurasia and Gondwana, over a revolving core, on the whole southwards during

the Devonian and Carboniferous, when the motion became reversed with some anti-clockwise rotation as well. Thus arose a progressive shift across the face of the earth of the main climatic zones, and the progress of such a climatic "wave" would naturally result in changes of biological environment, and therefore of evolutionary influences. He concluded by saying that although the marine fossils would generally constitute a fairly consistent geological clock, palæo-botanists should have no hesitation in stressing the plant evidence, should the latter be weighty, although at the moment, their conclusion may be at variance with that drawn from the associated marine faunas.

Several other valuable contributions were received for this symposium by such eminent geologists and palæontologists as Prof. W. Gothan (Berlin), Dr. T. W. Stanton (Washington), Prof. T. D. A. Cockerell (Colorado), Prof. E. W. Berry (Baltimore). Prof. H. C. Sze (Nanking) and Dr. A. B. Walkolm (Sydney); but in the absence of the authors, these communications had to be taken as read.

Boundary Faults in The Sub-Himalayas.

"The Significance of Boundary Faults in the Sub-Himalayas," was the subject of an interesting discussion held on Wednesday, 5th January, under the presidentship of Mr. D. N. Wadia of the Geological Survey of India.

Mr. P. Evans (*Assam*) referred to the hypothesis developed by Middlemiss following up a suggestion of Medlicott, which postulates that the faults within the tertiary strip of the sub-Himalayas are 'boundary faults' marking very closely the original limits of deposition of the successive groups. This conception of 'boundary faults' is still accepted as the orthodox interpretation of the structure and stratigraphy of the sub-Himalayan zone. But the recent detailed mapping in Assam has shown that the Disang thrust fault of the Naga Hills is not a south-eastern limit of deposition as suggested by the 'boundary fault' hypothesis. This and some other considerations seem to point to the need for the re-examination of the evidence on which the hypothesis is based. An alternative explanation which may be offered is that the faults are in the main of post-miocene age, largely contemporaneous, and have no close connection with the limits of deposition of the eocene and miocene beds. The object of the discussion is to consider the evidence for and against these two explanations, and it seems impossible to obtain any clear picture of the Himalayan mountain-building movements until such a fundamental contradiction is resolved.

Mr. D. N. Wadia (*Calcutta*) said that geotectonic work in the Punjab sub-Himalayas helped to define the real boundary of the Himalayas, *i.e.*, the limit of the geo-synclinal deposits against the epi-continental and fluviatile deposits laid down on the marginal foreland, and which have been involved in the later subsidiary phases of upheavals. This boundary is a well-defined thrust-plane, and the term 'main boundary fault' applied to this fault, is clearly a misnomer. South of this thrust-plane are a system of more or less parallel reversed faults which appear to be true 'boundary faults' as conceived by Medlicott and Middlemiss, and these are highly characteristic of the Punjab, Kumaon, and Garhwal Siwaliks. At the western and eastern ends of the Himalayan arc, the characteristics of the boundary faults change, and they cease to be original limits of deposition marking the southwardly advancing foot of the Himalayas at the successive uplifts. The old conception that the faults mark cliff faces of the southern front of the Himalayas, against which piles of sub-montane sediments were laid down, could only be true in a very limited and general sense at the most typical localities.

Prof. P. G. H. Boswell (*London*) agreed with the views expressed by Mr. Evans and doubted whether any 'boundary faults' of the kind conceived by Medlicott and Middlemiss, ever existed in India or elsewhere; for instance, he said that such a term was never used in describing the structure of the Alps. He did not think that these faults had anything to do with the original limits of deposition.

Prof. F. K. Morris (*U.S.A.*) also concurred with Mr. Evans, and Prof. Boswell, and said that there is no reason to believe that these faults in the sub-Himalayas mark the original limits of deposition of successive beds, as implied by the term 'boundary fault' used by Indian geologists.

Sir L. L. Fermor said that the term 'boundary fault' had better be used in the more general sense as merely indicating a fault that forms the 'boundary' of a formation, without implying any idea of its indicating an original limit of deposition.

The Origin of Banded Gneisses.

A symposium on this subject was held on Friday, the 7th January, under the Chairmanship of Mr. D. N. Wadia, President of the Geology Section.

Mr. B. Rama Rao (*Bangalore*) opened the discussion and gave a brief account of the several types of banded gneisses recognised in Mysore. These, he said, may be broadly classified into 3 divisions: (1) banded ortho-gneisses, (2) banded para-gneisses, and (3) banded composite gneisses. In group (1), the banding is due to several causes such as the parallel orientation of coloured minerals in deformed granitic rocks, the acid injection along the planes of weakness of the hornblende schists, incorporations of streaks and stringers of the dark hornblende schists in the granitic rocks, etc. Under group (2) there are rocks like the sillimanite-cordierite-gneiss, and the kyanite-sillimanite-gneiss, where the banding is due to the crystallisation of different layers of original sediments. Among (3) the banded composite gneisses, may be mentioned certain garnetiferous migmatic gneisses and cordierite-hypersthene-gneisses where the banding is seen to be due to lit-par-lit injections of acid veins in the original sediments.

Dr. M. S. Krishnan (*Calcutta*) referred to the banded gneisses observed in the Gangpur-Ranchi area of Chota Nagpur, and said that there were three types of these, *viz.*, biotite-gneiss, calc-gneiss, and amphibolite-gneiss, in all of which the lighter bands were of aplitic or granitic material injected into the rocks in lit-par-lit fashion. He drew the attention of the

house to the recent experimental work of Goranson (of the Geophysical Laboratory, Washington) which shows that pegmatite and aplite crystallise within a temperature range of 700° to 500° C. and quartz veins at still lower temperatures. Thus granitic magmas at a depth of a few kilometers can be expected to give sufficient residual fluids to soak or to penetrate porous and schistore rocks in their neighbourhood, and give rise to granitization and banding.

Mr. L. S. Krishna Murthi, Dr. C. Mahadevan, and Mr. Syed Kazim (Hyderabad-Deccan) in a joint communication gave an account of the banded gneisses they had studied in Raichur and Gulburga Districts, and said that the banding in these gneisses may be classed under two heads:—(1) banding in the grey series produced by aplitic and pegmatitic phases of the same series, and from injections of the pink series and (2) banding in both the grey and the pink series, produced by long runs of basic rocks, as seen in the contact zones of the schists and gneisses.

Prof. H. H. Read (Liverpool) put forward the view that all the banding in the gneisses and such other rocks is inherited from the original country rock, which itself already had some kind of banding; and that this original banding had, to a great extent, determined and controlled the nature of the banding in the derived gneisses. Often it is a case of an original sedimentary banding being reproduced in the metamorphic gneiss. He said he was not particularly happy about the term 'injection gneiss' since, in a way, the term begs the question. The idea of lit-par-lit injection, he said, is really applicable only in very few cases of rocks formed under very special conditions; and he did not believe that in any of the banded gneisses referred to by the previous speakers, there was a true case of banding due to injection of acid igneous material through basic rocks like hornblende schist: they appeared to him to be all due to the igneous metasomatism of an original already banded rock.

Prof. F. K. Morris (U.S.A.) from his knowledge of such banded rocks in America, and also parts of India, agreed entirely with the views of Prof. Read, and said that the term 'lit-par-lit injection' had better be altogether abandoned; and similarly also even the term 'injection'. The entire process involved may appropriately be called 'guided replacement'. He then referred to certain aspects of 'metamorphism' and showed how starting form shale, it was possible to derive schists, banded gneisses and even granites.

Dr. A. L. du Toit (S. Africa) supported the views of Prof. Read and said that the idea of replacement in the production of banded gneisses is being more and more recognised. The present orthodox nomenclature in describing these banded rocks should be abandoned, and we must also cease to think that high pressure was responsible for producing banding and contortion. The change from a sedimentary bed to a banded gneiss could be effected at a fairly low temperature and a relatively low depth.

Pre-Cambrian Sedimentation.

An interesting symposium on 'Pre-Cambrian Sedimentation' was held on Sunday, 9th January. Mr. D. N. Wadia, President of the Geology Section, was in the chair.

Sir L. L. Fermor in opening the symposium, said that the term 'Pre-Cambrian' in such a discussion must be used in the more general sense so as to include all the period of time before the deposition of the Cambrian strata. He gave a brief review of the pre-Cambrian rocks of India, and drew pointed attention to some of the special features noticed among these formations, for many of which, he said, satisfactory explanations have yet to be put forward.

Prof. L. Rama Rao (Bangalore) discussed a few aspects of pre-Cambrian sedimentation in general. After pointing out a number of facts which one has to remember in discussing any aspect of pre-Cambrian geology, he said that in the study of pre-Cambrian sedimentation, three questions naturally come up for consideration: (i) what was the appearance of the face of the earth at the beginning of geological history; was there a world sea encompassing the whole earth, or were there, as now, continental blocks and sundering oceans? (ii) was the character and composition of these primeval oceans, and of the atmosphere under which they lay, the same as it is now; and were the processes of sedimentation, chemical, mechanical and organic, similar to those of the present day? and (iii) what part, if any, did life play in the building up of these ancient rocks? In dealing with the second question, he discussed how far a rigid adherence to the doctrine of uniformitarianism is reasonable or helpful in interpreting the past history of the earth during this prolonged period of remote antiquity covered by the pre-Cambrian. Regarding question (iii), he said that, taking into account all considerations, there seems to be no doubt that many more forms of life flourished in the pre-Cambrian period than the actual fossil record indicates. The pre-Cambrian seas must have been teeming with life of a kind which could never be preserved in the fossil condition, but nevertheless played an important part in initiating and directing the course of contemporary sedimentation.

Mr. B. Rama Rao (Bangalore) talking about the main features of sedimentation of the Archæan times as exemplified in the Dharwar rocks of South India, said that the process of sedimentation of this extensive era may be considered under three periods: (1) the oldest period when there was a dominance of vulcanism with hardly any sedimentation; the few probable sediments are of the nature of chemical depositions—mainly siliceous; (2) during the second period, there are evidences of there having existed meteoric conditions, more or less similar to those of the present day; there was still a considerable amount of chemical deposition, lime, iron and silica being the common products of precipitation; (3) this last period indicates conditions of sedimentation not very different from what are commonly seen at the present day; the disintegrated products of rocks were transported, sorted, and deposited like the present-day sediments.

Dr. M. S. Krishnan (Calcutta) said that, of the sedimentary types in the pre-Cambrians, the iron formations and the manganiferous rocks are peculiar in that their deposition has not

been repeated in later ages to a similar extent or magnitude After giving a brief account of the nature and distribution of these deposits in India, he said that though iron and manganese occur in close association in rocks and minerals, on going into solution, they tend to be segregated during deposition—the abundance of oxygen determining whether carbonates or oxides will be deposited.

Prof. H. H. Read (Liverpool) believed that the conditions of pre-Cambrian sedimentation were more or less the same as those of later times, and saw no reason to appeal to any 'non-uniformitarian' principle. He said that almost all the rock types of the pre-Cambrian period are matchable among post-Cambrian formations, except the biogenic rocks of the latter.

Prof. P. G. H. Boswell (London) said that according to the idea of uniformitarianism as modified by Sollas, it is possible that the dynamical agents, though they have never varied in kind, may have still varied in the intensity of their action during former geological periods; and this will probably serve to explain all aspects even of pre-Cambrian geology. Talking of the limestones, he said that in their formation, it is often very difficult to draw a line between chemical precipitation and organic origin—the two agencies were so closely intermixed. It is quite probable that life played quite an important part in their deposition. The iron ores, which form such a unique feature of the pre-Cambrian in many parts of the earth, very probably owe their origin to the action of bacteria. Algæ and bacteria were the two groups of primitive life which seem to have played a large part in pre-Cambrian sedimentation. He thought a spectroscopic analysis of pre-Cambrian graphites may throw some light on their origin.

Prof. W. G Fearnsides (Sheffield) said that in reviewing earth history in general, it will be seen that each major formation has some particular type of rock constituting its speciality. In the case of the pre-Cambrian, the iron ores occupy this position. These must have been formed due to a peculiar combination of special conditions.

Prof. F. K. Morris (U.S.A.) talking of the life of the pre-Cambrian, said that the highly organised character of Cambrian life makes it absolutely necessary to believe in a long process of evolution of pre-Cambrian life from the primitive unicellular condition to the Cambrian stage. We should also realise that the protozoan cell itself is really not so simple and primitive a structure as it is commonly believed to be; it is a most complicated structure, and must itself have been derived as a result of an equally long process of evolution from much smaller and simpler specks of life which may be termed 'moleculobiontia'. There is no doubt that the pre-Cambrian seas were literally teeming with life which must have played a large part in the formation of contemporaneous marine deposits.

L. RAMA RAO.

The Tenth Conference of the Indian Mathematical Society.

THE Tenth Conference of the Indian Mathematical Society was held at Lucknow under the auspices of the Lucknow University on the 15th, 16th and 17th of March 1938. Dr. R. P. Paranjpye, the Vice-Chancellor of the Lucknow University, served also in two other capacities as the Chairman of the Reception Committee and as the President of the Indian Mathematical Society. In his welcome address, Dr. Paranjpye referred to the good and continually enlarging sphere of work done by the members of the Society, and laid emphasis on the need for a detailed scheme of work regarding the History of Mathematics in India. He pointed out that the Indian Mathematical Society was pre-eminently fitted to make authoritative investigations in this field, and suggested that the Society should immediately set to work in this direction.

The Conference was declared open by the Hon'ble Mr. Govind Vallabh Pant, Premier of the United Provinces, in an *extempore* and exceedingly humorous speech, in the course of which he referred to the outstanding contributions of early Indian Mathematicians, such as the introduction of the decimal system. The Premier expressed the hope that the holding of the present Conference of the Society at Lucknow would serve as a stimulus to the progress of mathematical research in the U.P.

Dr. R. Vaidyanathaswamy of the Madras University, then delivered the Presidential Address on the 'Philosophical Foundations of Mathematics'. A full text of his address will appear in the *Mathematics Student* in due course.

About forty papers dealing with diverse mathematical topics were presented to the Conference, and many of them elicited useful discussions on the subject. Besides these, a symposium was held on the 'Relative Merits of Einstein's and Sulaiman's Theories of Gravitation,' the symposium being led by Sir Shah Sulaiman, Prof. Narlikar and Prof. A. C. Banerjee. There was also a brief address by Prof. Vijayaraghavan on Tauberian Theorems.

There was also a brief discussion as regards methods of teaching mathematics. Finally, as regards the systematisation of research on the history of mathematical development in India, a Select Committee was constituted to draw up a report to be submitted to the Committee of the Indian Mathematical Society.

Three popular lectures, meant for the general public, were delivered: "The Theories of Gravitation," by Sir Shah Sulaiman; "Stars and Galaxies," by Prof. A. C. Banerjee; "Properties of Numbers," by Prof. T. Vijayaraghavan.

The Conference was attended by delegates from almost all parts of India. The success of the Conference was due to the enthusiasm of Dr. R. P. Paranjpye, assisted by Prof. Strang, Dr. A. N. Singh and a band of energetic volunteers.