of success, greater than in Economics. Economists for a long time were content with qualitative analysis, but in recent years there has been both a recognition of the need for, as well as a *growth* of, quantitative measurement. Sir M. Visvesvaraya's work is a gratifying indication to the World of Science that we in India are aware of recent developments in this important field of study.

N. S. S. R.

Some Recent Advances in Indian Geology.*

By W. D. West,
Geological Survey of India.

3. The Geology of the Himalaya. †

THE SIMLA-CHAKRATA HILLS.

WE may now consider the second area within the Himalaya which has of late received attention from the Geological Survey of India. In 1925 G. E. Pilgrim and W. D. West began a resurvey of the country between Simla and Chakrata, and were later joined by J. B. Auden. This area had first received attention from H. B. Medlicott so long ago as 1860, and was subsequently the subject of several papers by R. D. Oldham and others. It was Medlicott, however, who laid the foundations of our knowledge of this part of the Himalaya.

A feature of the geology of much of this country, which puzzled Medlicott and subsequent observers, is the occurrence of highly metamorphosed rocks, such as garnetiferous mica-schists and amphibolites, resting on top of practically unaltered rocks, such as the Simla slates. According to Pilgrim and West, these rock groups are not now in their original position relative to one another.[21] Detailed mapping and metamorphic considerations have led them to conclude that the metamorphic rocks, which are really part of the belt of rocks forming the central axis of the Himalaya, have been forced southward for many miles along a nearly horizontal thrust plane, so as to lie now on top of the unaltered rocks. These metamorphic rocks, named the Jutogh series, are seen forming the upper part of the ridge on which Simla is built, the small hill station of Chail, and the greater part of the Chaur mountain south-east of Simla. At the two former localities they occur as true 'klippe', since the effects of denudation have left them as isolated outliers capping the two hills. But the outcrop that forms the greater part of the Chaur mountain continues northwards along a high ridge, and so joins up directly with the main mass of crystalline schists and granites north of the Sutlej river. The Chaur outcrop is thus a direct southward extension of the rocks of the central axis of the Himalaya, and the way in which these metamorphosed rocks extend so far south as a nearly horizontal sheet, overlying the less metamorphosed slate-limestone group of rocks, is one of the most striking features of the geology. In addition to the major thrust plane along which the Jutogh series have travelled, there are other thrust planes in the rocks below, of which the Chail thrust is the most important. The crush phenomena found along the line of this thrust afford evidence of considerable horizontal movement here also. It is possible that the oncoming of the uppermost Jutogh beds like a gigantic wave from the north, induced the formation of the underlying thrusts, the rocks being piled up one on top of the other as a result of great horizontal compression.

Intruded into the Jutogh series there occurs the porphyritic gneissose biotite-granite which forms the upper part of the Chaur peak. This is the same rock as Stoliczka's 'Central Gneiss', and is one of a long series of intrusions stretching from Garhwal to Nanga Parbat. According to Pilgrim and West, the foliation which is found locally in it was developed at the time of its intrusion. Around the granite there is a definite increase in the grade of metamorphism of the Jutogh series, producing very coarse garnet-staurolite-schists, whilst kyanite is sometimes found.

The underlying less metamorphosed rocks comprise a number of series which have been given local names. These include the Chail, Simla, Jaunsar, Krol, Shali, Deoban and Tal series, together with the thin but important Blaini beds, which are now thought to be homotaxial with the Talchir

* Published with the permission of the Director, Geological Survey of India.

† Continued from previous issue, *Curr. Sci.*, 1934, **3**, 231.

[21] *Mem. Geol. Surv. Ind.*, 1928, **53**.

beds of Peninsular India, as first suggested by Oldham. The age of the rest of the rocks is at present quite unknown, though certain deductions may be made. These less metamorphosed rocks have been studied and mapped in detail by Auden along a narrow belt of country lying immediately south-west of the country mapped by Pilgrim and West, extending in an E.-S.-E. direction from Solon on the Kalka-Simla railway to the southern part of the Chakrata district.[22] It seems clear from his work that the rocks of this Krol belt are a thrust mass of Jaunsar-Blaini-Krol-Tal rocks, resting on a floor of Simla slates and Tertiary rocks, from which they are separated by the Krol thrust, which is itself folded. The details of the structures are too complicated to allow of easy summary, but, broadly speaking, there are two thrust-bound synclines overturned towards the south, the northern syncline being brought on by the Giri thrust, and the southern by the Krol thrust. The latter is the more important of the two, separating the Tertiary rocks from the pre-Tertiary. Oldham's 'Main Boundary Fault' comes still further to the south-west. East of Nahan the two latter thrusts meet, the Krol thrust appearing to overlap the other. Towards the south-east end of the belt the northern syncline opens out and includes a mass of Tal rocks, which overlie the Krol rocks unconformably. It will be remembered that comminuted fossils have been found in the Tal rocks of the type locality in Garhwal, but too damaged to be identified. In the southern portion of the Chakrata district, by and east of the Tons river, this belt of rocks is bounded on the north side by another thrust, the Tons thrust. As this thrust dips to the south and south-west, and as the Krol thrust on the south side of the belt dips northwards, it is suggested that the two thrusts are the same and join below, and that the great syncline of Jaunsar rocks, with overlying Krols and Tals, rests as a nappe on a folded thrust plane. The component beds of the two synclines are much folded, but this folding is not regarded by Auden as of structural significance, but as due to the incompetent nature of the beds. The two synclines have behaved as units, which have moved *en bloc*.

A point stressed by Auden is that too much emphasis has in the past been laid on a single 'Main Boundary Fault' as having borne the burden of the advance of the Himalaya, and in particular he rejects Lake's simple explanation of mountain arcs, which has already been referred to. As Middlemiss showed long ago, in addition to Oldham's 'Main Boundary Fault' there are several comparable faults within and bounding the Siwaliks on the one hand, and within and bounding the pre-Tertiary rocks on the other hand. And the more recent work on these latter rocks has only served to extend these observations, and to emphasise the importance of these other thrusts.

As regards the time of intrusion of the gneissose granite which is found in the Jutogh series, and similar granites elsewhere, *e.g.*, Lansdowne, Dudatoli, and the main mass of the Dhaoladhar range to beyond Dalhousie, which seems to be identical with what Stoliczka called the 'Central Gneiss', Pilgrim and West, while refraining from expressing any definite opinion except that it was probably pre-Chail in age and possibly Archæan, rejected McMahon's view that the intrusion took place during the Tertiary at the time of the upheaval of the Himalaya. Auden has now gone further, and has put forward reasons for supposing the intrusion to have taken place towards the end of the Palæozoic, suggesting that it occurred in connection with certain crust movements which he thinks took place in pre-Infra-Krol times, along a line coincident with the line of the old Aravalli mountains if continued north-eastwards from Delhi towards the Himalaya. This recognition of an older structure subordinate to the main Kainozoic structure of the Himalaya in these hills may prove to be important, though it would be surprising not to find evidence of some such break, considering the importance of the break between the Dravidian and the Aryan in so many parts of India. The suggestion that it is an Aravalli structure (based on the direction of minor folds in pre-Infra-Krol rocks, and the direction of orientation of phenocrysts in the Lansdowne granite) must await the results of further observation. Nevertheless it has received considerable support from the gravity investigations of the Survey of India, which suggest that there is an upward buckling of the floor of the Gangetic trough along a line stretching

[22] *Rec. Geol. Surv. Ind.*, 1934, **67**, 357.

from Delhi towards Saharanpur.[23] In an earlier paper Auden discussed the age of certain Himalayan granites, and arrived at tentative conclusions based partly on such tectonic considerations.[24] According to him it seems definite that some of the granites of the Central Himalaya and border ranges closer to the Peninsula were intruded in pre-Triassic times, and belong to pre-Himalayan tectonics, though they are probably of more than one age. Considering very generally this question of the age of Himalayan granites, it appears from recent researches that the youngest type is a tourmaline-granite, the intrusion of which must have taken place in very late Kainozoic times. Another which is common in many parts of the Himalaya is a hornblende-granite with sphene and sometimes epidote. Around Nanga Parbat and in Ladakh it has metamorphosed the Panjal trap, while a similar granite is post-Cretaceous in age in the Everest region.[25] Of probably older age is the porphyritic gneissose biotite-granite, Stoliczka's 'Central Gneiss', so frequently referred to above. It is definitely post-Dogra slate in age, and, according to Wadia, is post-Carboniferous in the Pir Panjal.[26] Finally, pebbles of older granites have been found in the Panjal Agglomerate, in the breccia at the base of Middlemiss's Purple Slate series, and elsewhere. It is thus clear that there are a number of granites in the Himalaya of different ages; but their relative importance, and the part that any of them may have played in the Kainozoic mountain building movements, or in the metamorphism of Palæozoic sediments to crystalline schists, cannot at present be determined with certainty, and will have to await the detailed mapping of one complete section of the Himalaya.

In discussing the metamorphism of the rocks of the Krol belt, which is of a low *epi* type, Auden suggests that the greater metamorphism displayed by the rocks in the Chaur area further north-east is due entirely to the intrusion of the Chaur granite, and rather infers that had there been no granite then the rocks would have displayed no greater metamorphism than the rocks of the Krol belt.[27] His views are based on a general consideration of the metamorphism displayed by the rocks in the Simla area, and in particular on a visit to Lansdowne and an inability while there to find any discordance separating the garnetiferous schists surrounding the Lansdowne granite from the less metamorphosed rocks further away. This is contrary to the opinion expressed by Pilgrim and West, who regarded the Jutogh series as an older set of rocks which everywhere display a *meso*-grade of metamorphism, locally intensified by the Chaur granite. They were impressed with the importance of the Jutogh thrust, which has brought the Jutogh rocks, together with the Chaur granite and its associated igneous rocks, into contact with rocks displaying only an *epi*-grade of metamorphism, or no metamorphism at all. They fully realised, however, the possibility of the Jutogh and Chail series both being older than the metamorphism, which might have metamorphosed them to different grades before the thrusting brought them into juxtaposition. The matter is referred to at some length here because it is a problem of prime importance. Leaving out of consideration the evidence for the Jutogh thrust, it is really a problem of explaining how, on the assumption that there has been no thrusting, the uppermost rocks with a roughly horizontal disposition have come to be intruded with granites, while the underlying rocks have escaped the intrusion. The presence of the Jutogh thrust between the two sets of rocks explains the anomaly, but it is a solution which may have only a local application, and of course throws no light on the relative ages of the rocks. In an unpublished report on traverses in Eastern Nepal, Auden has developed his point of view a step further by definitely suggesting that the Daling series pass up by increasing metamorphism into Darjeeling gneiss, the latter consisting mostly of para-gneiss and schist. Here again the more metamorphosed rocks, with their accompanying ortho-gneiss and granite, overlie the less metamorphosed Dalings. According to Auden the two are the same, the Dalings belonging to the *chlorite* zone of metamorphism and the Darjeeling gneiss to the combined *biotite-garnet* zones. This question of the age or ages of the crystalline schists in the Hima-

[23] *Geodetic Report*, 1933, **8**, 57.

[24] *Rec. Geol. Surv. Ind.*, 1933, **66**, 461.

[25] *Op. cit.*, 1932, **66**, 224; and *Mem. Geol. Surv. Ind.*, 1907, **36**, 183-184.

[26] *Mem. Geol. Surv. Ind.*, 1928, **51**, 223.

[27] *Rec. Geol. Surv. Ind.*, 1934, **67**, 406-419.

laya is full of difficulties and will possibly only be solved in an area where there is no extensive thrusting. The problem is an important one, and with it is bound up the question of the age of some of the granites.

Some 40 miles north-west from Simla, in Mandi State, S. K. Roy has noted folded dolomitic limestones, which he suggests may be Krol in age, resting partly on Kainozoic rocks and partly on slate and volcanic rocks of pre-Kainozoic age.[28] He suggests that these limestones are 'klippe' of older rock resting on younger rocks, their roots being found in Kulu some 16 to 20 miles further east.

As regards the age of the thrusting, Auden has pointed out that the Krol thrust near Kalsi brings the pre-Tertiary rocks to rest upon Nahaus. The thrust must therefore be of Upper Miocene or later age. As bearing upon this same question, interesting evidence has very recently been brought forward (but not yet published) by H. M. Lahiri, working between Nalagarh and Anandpur, that is along the edge of the foothills nearly due west of Simla. Over a distance of about one and a half miles Lahiri has found Dagshai beds (Miocene) resting horizontally or with a slight south-westerly dip on the top of boulder conglomerates belonging to the Older Alluvium (Pleistocene). It seems clear that the Dagshai beds must have been thrust over the younger boulder conglomerates, and the thrusting must have taken place in late Pleistocene or very recent times.

One of the most remarkable features about these Simla series—Krol series set of rocks is the complete absence of fossils in them, making it difficult to determine the age of the rocks. The Blaini beds with their supposed glacial boulder bed may reasonably be regarded as homotaxial with the Talchir boulder bed of Peninsular India, and therefore to be of Upper Carboniferous age, though the point is not beyond dispute. But beyond that little can be deduced. It may be asked, how is it that while the thick series of sedimentary rocks on the Tibetan side of the central axis are fossiliferous, and include rocks ranging in age from the Cambrian to the Eocene, the sedimentary rocks on the southern side of the axis are completely unfossiliferous, though they include rocks which must have been formed at the same time. The question is a difficult one to answer. It may be due partly to the fact that many of the limestones of the Simla area are dolomitised, during which process the fossils may have been destroyed. But there are many other rocks such as slates and shales, suitable for the preservation of fossils, which have undergone little or no alteration. Yet so far not even the trace of a fossil has been found in the pre-Tertiary rocks. It is possible that during the long period of time during which deposition was proceeding, the sea over the Simla area was separated from the northern sea or Tethys by high land over what is now the central axis of the Himalaya. And it may be that the physical conditions of this southern sea were unfavourable to the presence of abundant life. That this may have been so is evident from the shallow water nature of many of the rocks, from the evidence which they provide of having been formed under unhealthy conditions, and from the fact that desert conditions may have prevailed over the adjacent land areas, as suggested by Auden.[29] Between the Simla hills and Spiti there occurs the broad belt of the crystalline schists and gneisses forming the central axis of the Himalaya, so that continuous mapping of the limestone-slate series from one area to the other is impossible. Attention, however, may be drawn to the fact that further north-west, to the south-east of Chamba, judging from our scanty knowledge of the geology as represented on the 32 miles to the inch geological map, this dividing belt of crystalline schists is for a short distance very thin. It may be that we have in this locality the opportunity of correlating the unmetamorphosed sedimentary rocks of the two belts. Further north-west, towards Kashmir, there occurs a mingling of these northern and southern seas, and fossils begin to appear. But the exact age of the rocks in the Simla area will not certainly be known until fossils have been found in them, or until continuous mapping has been completed between Simla and Kashmir or between Simla and the Chamba to Spiti section.

COMPARISON BETWEEN SIMLA AND KASHMIR.

Comparing broadly the structure of this section of the Himalaya with the Kashmir area in the light of recent work, it seems

[28] *Quart. Journ. Geol. Min. Met. Soc. Ind.*, 1933, **5**, 131.

[29] *Rec. Geol. Surv. Ind.*, 1929, **62**, 168.

that the sedimentary rocks of the Krol belt correspond to Wadia's autochthonous zone in Kashmir; while the Jutogh and Chail series and the gneissose-granite correspond to Wadia's nappe zone. *Auden's Krol* thrust corresponds in position to Wadia's Murree thrust, and Pilgrim and West's Jutogh thrust (or possibly their Chail thrust) to Wadia's Panjal thrust. The chief difference between the two areas is that whereas in Kashmir several basins of fossiliferous sedimentary rocks are found resting in synclines on top of the Kashmir nappe, in the Simla hills-Spiti area nothing similar is seen until one reaches Spiti on the north side of the central axis. It is possible that such rocks once occurred further south than Spiti but have since been denuded away or have been so metamorphosed as to be now unrecognisable.

EASTERN HIMALAYA.

Proceeding further south-east along the range, it has to be regretted that little advance has been made of recent years in our knowledge of the geology of this portion. So long ago as 1875 H. B. Medlicott published a note on the geology of Nepal, which was based on observations made during a journey along the main road to Khatmandu, and from there north-west up to Nayakot.[30] During this journey Medlicott found in a limestone on the crest of the Chandragiri pass 'some small facets of spar having a central puncture, and which I took to be crinoidal; but Dr. Waagen would not say positively that they were so'. Quite recently both Sutton Bowman and Auden have procured better specimens from the same locality, and there is now no doubt about their being fossils. They have been examined by Lahiri, who has identified them as cystids together with the brachiopod orthis. The interest of this discovery will be realised when it is remembered that this is the first discovery of cystids anywhere in the Himalayan area, these fossils having previously been found only in the Burma province. The rocks in which they occur must therefore be of Lower Palæozoic age, though *it still remains to correlate them with rocks in adjacent tracts.*

As already mentioned, Auden has made traverses recently in Eastern Nepal. As a result of this work he has been able to demonstrate with certainty the continuation westwards from Darjeeling of the Darjeeling gneiss and the Daling series. As noted above, he regards the two as belonging to the same series, but differently affected by metamorphism. Amongst the Tertiary rocks *along the southern border of the hills* he found *Middle* and *Upper Siwaliks dipping* northwards beneath Nahan or Lower Siwalik rocks. There must clearly be a thrust plane separating these two groups, while the Tertiary rocks as a whole are separated from the pre-Tertiary by another thrust, in a manner similar to that found in the Simla-Mussoorie area.

THE MOUNT EVEREST AREA.

In 1921 Dr. A. M. Heron accompanied the Mount Everest Reconnaissance Expedition, and examined an area of over 8,000 square miles around the Arun river and its tributaries, to the north and east of Everest.[31] This is a continuation westwards of the country surveyed by Hayden in 1903-4. The area examined by Heron is divided by him into a *northern or Tibetan zone*, comprising a thick series of highly folded Jurassic rocks, containing narrow synclines of Cretaceous and Eocene; and a southern or Himalayan zone, in which Everest lies, consisting of foliated biotite-gneisses full of dykes and sills of tourmaline-granite and pegmatite. Between these two zones there lies an intermediate zone of metamorphosed sedimentary rocks, regarded by Heron as metamorphosed rocks of the Tibetan zone. These rocks have a northward dip, so that the gneisses pass upwards into the metamorphic rocks, and the latter upwards into the Jurassic rocks. The metamorphosed sedimentary rocks include crystalline limestones, and actinolite- and epidote-schists. Ascending northwards in the succession the metamorphism decreases, and fossil Spirifer and Productus were found by Heron in the limestone. These rocks in turn pass up into the unmetamorphosed Jurassic rocks. The metamorphic rocks are therefore regarded by Heron as Permian or Triassic in age. According to L. R. Wager, who accompanied the last Mount Everest expedition in 1933, these metamorphic rocks include an upper series of quartzites and shales containing a brachiopod fauna of probable Lower *Permian age, underlain by* a limestone about 2,000 feet thick, which forms the summit of Mount Everest, and which is probably either Permo-Carboniferous or Carboniferous in age.[32] This in

[30] *Op. cit.*, 1875, 8, 93.

[31] *Op. cit.*, 1923, 54, 215.

[32] *Nature*, 1933, 132, 976.

turn is underlain by a pelitic series much injected by granite. As regards the Darjeeling district, Wager suggests that the Daling series are the equivalent of the Everest pelitic series, while he agrees with the large-scale inversion suggested by Mallet.

Before concluding this section reference must be made to a new edition of Burrard and Hayden's *A Sketch of the Geography and Geology of the Himalaya Mountains and Tibet*, first published in 1908. In the new edition, published this year, the part dealing with the geology has been brought up-to-date by Dr. A. M. Heron, and it should be in the hands of every geologist interested in Indian geology.

Cerebro-Spinal Meningitis.

By Capt. P. Ganguli,

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History.

IN 1805, an epidemic of cerebro-spinal meningitis occurred in Geneva and Vieusseux was the first man to describe the disease. In 1806 and 1807, the disease was prevalent in the Prussian army. From 1805 to 1830 it occurred in the United States of America and gradually spread from east to west. France was next attacked in 1837 and the disease spent its force in 1874. From 1854 to 1874, the disease occurred both in Europe and in America. From 1875 till now, the disease has spread throughout Europe and America and many places of Asia.

The present Indian epidemic started in the beginning of 1932 in Calcutta, when nearly 40 cases were admitted to the Calcutta Medical College within a month. Subsequently all the cases were admitted to the Campbell Medical School. The disease continued in its sporadic form and has now spread throughout Northern India.

Epidemiology.

Age.—Children are more susceptible to the disease than adults. In the Danzig epidemic, 93 per cent. were under 5 years of age. In Calcutta, however, the disease is particularly prevalent amongst adults. Majority of the cases among children were of chronic character.

Sex.—In Calcutta, more males were attacked than females. As fatigue, chill and overcrowding are predisposing factors, the adults are more liable to infection than others. The purdah system is responsible for keeping the women indoors. The incidence is therefore less among the women. In certain cases, however, where women were exposed to overcrowding, the disease attacked them as well.

Example.—A female came from a moffussil to Calcutta for the anti-rabic treatment of her son. She had to attend the crowded out-door of the Pasteur Institute in the School of Tropical Medicine and Hygiene, and ten days after, she contracted cerebro-spinal meningitis and died within three days of the attack.

The congregation of individuals in meetings, cinema houses, markets, big railway stations, third class compartments, and such like are favourable to the formation of multiple foci and spread of the disease. In well-equipped jails, barracks and schools of Calcutta, however, no cases have been reported. One case was reported from Dumdum jail amongst detenues. According to Major Malaya not a single case has been reported from the Calcutta police lines with a population of six thousand.

The lowered vitality of the population owing to depressed economical condition must be one of the factors. Bad sanitary conditions of the Northern part of Calcutta was responsible for the larger incidence of the disease in that part of the city. The disease is not, however, highly contagious and is not spread by clothing.

Season.—In the case of the European epidemics, the incidence is usually very high in winter whereas in Calcutta, in 1932, the highest incidence was recorded in the months of April and May. 20 per cent. of the cases gave history of exposure to mid-day sun.

Mode of the spread of the disease.—Weigert found presence of purulent rhinitis in many cases of cerebro-spinal meningitis. The meningococci are also found in the nose of many healthy persons, who are the carriers of the disease. The habit of many people to blow out the secretions of their nose indiscriminately in rooms and streets is responsible for the dissemination of