# REVIEW

HIMALAYAN GEOLOGY. Vol. 1, 1971, 311 pages. Edited by A. G. Jhingran, Wadia Institute of Himalayan Geology, Delhi. Hindustan Publishing Corporation (India). Rs. 40.

The Editor of the Journal has asked me to review the first volume which has been issued from the Wadia Institute of Himalayan Geology. To review this work after a period of 33 years absence from sustained field work in the Himalaya brings nostalgic memories of a time when a mere handful of officers in the Geological Survey of India, a few academics from Indian Universities, together with geologists attached to occasional expeditions from the continent of Europe, made up a very limited field of research workers. An element of personal regret moreover exists that the 1939-1945 war necessarily diverted those of us in the Geological Survey of India from purely tectonic studies in the Himalaya, except in regard to investigations of mineral occurrences, dam sites and tunnel alignments, so that no synoptic study ever later became possible. It was left to Gansser (1964) to produce the first synthesis of the whole range in a book which will remain a classic long after further work will modify and extend the interpretation of mountain structure.

The situation has now dramatically changed. In this present volume 15 contributions are made by 30 Indian geologists from 13 Universities, together with one contribution from the Geological Survey of India and one from the Indian National Science Academy. There are also eight reports by research fellows. It would appear that the Geological Survey of India prefers to operate on its own, for in a seminar (October 1971) devoted to recent geological studies in the Himalaya there are 62 contributors from the Survey. Again, the Oil and Natural Gas Commission is scarcely represented, although it is obvious that much detailed work must have been done by that organisation in the Himalayan foothills in connection with the search for liquid and gaseous hydrocarbons. It would be a pity if research were to become polarised from rival camps, though of course the field is large enough, and an element of competition may stimulate investigation. It is impossible to discuss all the interesting work in this volume in a short review, and I shall confine my attention to seven papers which have a bearing on work with which I was connected in the now distant past.

The first paper, by S. K. Ray and K. Naha, concerns the structural and metamorphic history of the Simla Klippe and raises the question of the inverted metamorphic zoning within the Jutogh series, a problem which, however, concerns a much more extensive area in the Himalaya than just around Simla. Pilgrim and West (1928) were the first to consider the possibility of recumbent folding, and they related the metamorphism to a now eroded part of granite, remnants of which remain on Chor peak in an outcrop 105 $km^2$ in area. Aside from the vertical variation in metamorphism is the question of lateral gradation within rocks of the same group. C. S. Middlemiss (1887) demonstrated the existence of the garnet aureoles around the Dudatoli and Lansdowne granites; and indeed garnets between 3 and 5 mm in diameter were being collected by villagers near Dudatoli in 1939 from weathered mica schist and used as shot in cartridges. The mica schists around both granites pass laterally into typical Chandpur phyllites, and there is no doubt that the Chandpurs are equivalent to the Chails. Hence, within the Chails there is a lateral and vertical variation in metamorphic grade which vitiates equating the more metamorphic rocks with a greater age.

It is in the Darjeeling Himalaya however that the inversion of metamorphic grades is most clearly seen. L. R. Wager drew his major thrust plane between the Daling phyllites and the overlying Darjeeling gneiss (1934, p. 327). Since the increase in metamorphism upwards is gradational it is not however possible to draw any definitive boundary between the Daling phyllites and the overlying gneissic rocks. This matter was discussed by me in 1935 (p. 163) as a result of traverses made across Nepal in connection with the Bihar-Nepal earthquake of 1934. It was also the subject of a letter by S. Ray to *Science and Culture* (1943, p. 353). The gradation was confirmed during three visits in 1965-1968 to the Mahabharat Lekh in eastern Nepal while studying diversion tunnel alignments. This conclusion is supported by work undertaken by Mukhopadhyay and Gangopadhyay (p. 213) in the volume under review, who agree with the zoning of S. Ray in the Kalimpong area and accept a gradational metamorphic boundary between the Dalings and overlying Darjeeling gneiss. Rather surprisingly, N. K. Singh, in a preliminary note (p. 279), denies the existence of metamorphic zones. Although he considers that the Dalings and Darjeeling gneiss belong to one stratigraphic unit, he regards the whole sequence as inverted. The major regional thrust is not, in fact, between the Dalings and Darjeeling gneiss, as was postulated by Wager, but between the Dalings and the underlying Gondwanas, which are exposed in a semi-window on the Sept Kosi around Barahakshetra, and as a window covering 100 km² along the Rangit valley in Sikkim, centred on coordinates 27°10′ : 88°20′ (A.M.N. Ghosh 1952, p. 135).

Returning to the Simla area, I have not felt altogether convinced by the validity of the thrust plane which was postulated between the Chail and Jutogh series, notwithstanding the lithological differences between the two formations. Ray and Naha consider, however, that there are many indications that the contact between the two formations is a thrust plane. The Jutogh series is similar to the Salkhala series of Wadia, and is identical to the pyritic schists, with pyrite seams up to 60 cm in thickness, graphite phyllites, marbles and quartzites which crop out on the right bank of the Indus river at the Tarbela dam (34°06′ : 72°42′). This group has been assigned in the 1964 Geological Map of Pakistan (scale 1 : 2 million) to the Lower Swat-Buner schistose group of Ordovician-Devonian age, and by Karl Stauffer to the Silurian-Devonian of the Swabi-Chamla group (1967, p. 550). The Salkhala series of Kashmir is evidently earlier than Cambrian, but this series is infested with post-Tanawal and post-Panjal volcanic granite intrusions, which cover an area of 2,000 km², or 20 per cent of that of exposed pre-Tertiary rocks north of latitude 34°10′ represented in Wadia's map (1934, plate 12). The Salkhala metamorphism is related to post-Palaeozoic granitisation and orogenesis, while fossils found in the Swat-Buner crystalline marbles, such as near the village of Tursak (34°31′ : 72°22′), indicate that those rocks are Palaeozoic in age, and succumbed to a post-Palaeozoic metamorphism. These indications find confirmation in the work of Sarkar, Reddy and Nair (1965, p. 689) in the Almora area where isotope determinations suggest a Lower Oligocene age for the metamorphism. Finally, Andritsky shows that the metamorphism of the Siah Koh area (34°20′ : 70°) in north-east Afghanistan is related to syn-orogenic granite-pegmatite intrusions of Upper Eocene to Oligocene age, (1967, p. 632).

The Chail-Jutogh boundary does not necessarily, therefore, separate an overlying older series from a younger one, whether it is a thrust plane or not. The decisive thrust plane would appear to be that which underlies the Chails, and was mapped by West between Kathlighat and Kiarighat, with beautiful precision separating Nummulitics and Dagshai beds from the overlying Chail phyllites north-east of Baraihna (31°12′ : 77°20′) in the Shali area (West 1939, plate 5).

Further, the distribution of stages within the Jutogh series near Simla does not suggest any symmetrical disposition in a recumbent fold, and the thick group of chlorite-sericite phyllites, grading to pin-head garnet schist, which contains important seams of pyrites north of Rahana at 31°04½′ : 77°10¼′, and occurs near the base of the Jutogh succession, is not duplicated upwards on Prospect hill and Taradevi. Current bedding is not normally well displayed in the Boileauganj quartzites, but in places, such as on the Rockdean spur near Taradevi, exposures indicate that the quartzites are not inverted, and these form the greater part of the upper half of the Jutogh sequence (Auden, 1953, p. 214). It would be interesting to apply the current-bedding technique to quartzites on the south face of Chor mountain, where there are four bands of marble which were tentatively regarded by Pilgrim and West as belonging to one single bed that had been repeated in two very tight recumbent folds (1928, plate 1 : Pascoe 1950, pp. 297, 300). There is a regularity of dip and lack of secondary warping in the marbles of the Chor area which would not normally be expected with recumbent folds of that degree of extension and overturning.

Not only is it certain, therefore, that the metamorphism of the Salkhalas and Chandpurs, and hence by inference of the Jutoghs and Chails, is post-Palaeozoic, but there is the possibility that the Jutoghs are younger than the Chails, Chandpurs and Hazara Slates. The geological map of the authors on page 3, as well as the map reproduced in the *American Journal Of Science,* (270, 30-42), is little changed from that of Pilgrim and West, who deserved some acknowledgment. The problems concerning the Jutogh and Chail rocks have been discussed at some length as they are, in fact, general to a great length of the Himalayan and related chains.

Niyogi and Bhattacharya (page 111) conclude that the Blaini boulder bed represents submarine slide deposits, but in the same volume Gaur (p. 231) considers that the Blaini in the Rishikesh area has three tillites, associated with interglacial sediments, a conclusion earlier reached by Gaur and Dave (1971, p. 164). It should be streassed that the Blaini of the type area, near Solon, has been mapped continuously to north of Lansdowne, over a distance of 200 km and the same sedimentary characteristics obtain throughout. Consequently, it would be expected that one mode of origin applies throughout the mapped distance of 200 km. That workers can come to opposed conclusions about the same formation regarding the mode of origin must mean that the diagnostic criteria are ambivalent. Particularly north-west of Solon, and in the case of the two boulder beds around the Mussoorie syncline, separated by 450-750 m of banded Blaini slates of varved type, one was led to favour the view that the boulder beds are tillites. It does not follow that all such boulder beds are tillites, and those associated with the Mandhali formation between Kalsi and Chakrata, and with the Bijni nappe around Lansdowne, may possibly have been formed by submarine sliding. Ganesan (1971, 257) has recently found Bryozoa associated with the Bijni boulder slates which indicates a Permo-Carboniferous age, roughly contemporaneous with the Talchir tillite. An inferred tillite is beautifully exposed near Barahakshetra on the Sapt Kosi, associated with coaly shale and dolomite, (Auden 1946, p. 346). In the Rangit tectonic window, exposing Gondwanas, to which reference was made above, Ghosh has described the association of tillite, 'pebble' beds, 20 outcrops of coal, beds with *Spirifer* and *Eurydesma*, and lamprophyre dykes, an assemblage not unlike that at Umaria, 850 km to the wsw. This window is 120 km ENE of the Barahakshetra semiwindow in Nepal. and 100 km SSW of the Lachi exposures described by L. R. Wager (1934, p. 333). Midway between the Peninsula and the Himalayan foothills is the exploratory well drilled 40 km northeast of Purnea, in which Metre has indicated the presence of 1223 m of Lower Gondwanas, with coal seams, and 399 m of Upper Gondwanas (1968, p. 47). A well at Kuchma (24°42′ : 89°17′) encountered a 6.4 m coal seam at a depth of 2712 m with a range of fuel ratio of 2.5 to 3.5, of typical Barakar character, associated with arkosic sandstones. It is evident therefore that there is a very large spread of Gondwana rocks extending from the Peninsula to the orogenically deformed section of the Indian continental plate.

The geographical extent of the boulder beds would have been even greater before telescoping of the northern edge of the Gondwana plate under the Tertiary orogeny. The extent and the overall nature of the rocks associated with the boulder beds, are suggestive more of glaciation than of submarine sliding. Sliding would be expected to be confined to the slope at the edge of the then continental shelf, and the resulting olistostromes in the piedmont below should have considerable linear extension but limited breadth.

Important though it is to determine the origin of a particular formation, a bed of peculiar lithology, if present over a sufficiently wide area, and with a constancy of position in the stratigraphical sequence, possesses an independent value as a mapping horizon, regardless of the ultimate (if indeed there is an ultimate) diagnosis of its nature. In this respect the Blaini was of great value four decades ago, even though it may have been too tacitly assumed by the writer and others to be related to the Permo-Carboniferous glaciation, an assumption which seemed gradually to gain strength from the definite Gondwana affinities of the boulder beds in the eastern Nepal and Sikkim Himalaya. In neither of the papers discussed above is there a geological map of the Blaini outcrops, which are beautifully displayed both along the Baliana river, and in the Ganga at Rishikesh, and deserved large-scale delineation.

Bhattacharya and Niyogi (p. 178) discuss the geological evolution of the Krol Belt, about the structure of which there has recently been a discussion between Ranga Rao and the reviewer (*Journ. Geol. Soc. Ind.*, v. 11, pp. 283-302). They appear to favour the interpretation of a thrust plane between the Blaini and the Nummulitic, an interpretation which brought me much disquiet in 1930 because of the imperfections in the outcrops, but which gained support from the windows exposed near Narendranagar that were found some years later.

A. K. Jain (p. 25) has produced a fine synthesis of the stratigraphy and tectonics of the lesser Himalaya around Uttarkashi. He disagrees with the concept of vertical tectonics which is favoured by the O.N.G.C. under the guidance of Eremenko, but he appears to attribute to me, amongst others, the idea of recumbent folding (p. 56). As discussed above, regarding the Jutoghs of the Simla area, I have been sceptical about the flat recumbent folding of the Jutoghs, and current bedding in the Tals and Jaunsars indicated that these beds, in the localities studied, are not inverted (1934, p. 392; 1937, p. 417).

In the chapter by Quereshy (p, 165), on geophysical investigations in the Himalaya, mention is made of the Bouguer gravity-low anomalies which are possibiy connected with the batholithic tourmaline granites of the main range (of probable Miocene age), and of a gravity high roughly coincident with outcrops of mafic rocks in the Garhwal tectonic window. The gravity high which runs between Rishikesh and

Naini Tal is possibly comparable to that of the piedmont zone in Italy between Pinerolo, Ivrea and Bellinzona. Gravity values are however subject to so many assumptions regarding corrections that it is to be hoped that a deep-seismic profile will be undertaken across the Himalaya in the manner carried out in the Alps and Pamirs. As described by H. Closs, (1965) the Moho discontinuity sinks from a depth of 30 km near Donau to 40 km at the north edge of the Bavarian Alps, with a gradient of 20° and a concomitant increase in the negative Bouguer anomalies. Under the Bernina Alps the discontinuity is at a depth of 65 km. Such figures may be compared with a depth of 70 km in the Pamirs as obtained by Soviet geophysicists from explosion seismic studies, and 81 km deduced by Qureshy from gravity results south of Mount Everest. It is doubtful however if any method would in fact provide such an exact figure.

In conclusion, the present volume is a fine collection of work concerning the Himalaya, which is well produced, with clear type and diagrams. That there are divergent views regarding the structure of the Himalaya is not surprising in view of the complexity of the problems. There is still lack of agreement about the structure of the western Alps which have been studied by the geologists of five nations during the last 150 years. It is good that the pioneer work of D. N. Wadia should now be perpetuated by the Institute after his name, and should be a source of encouragement to a new generation of geologists working with modern concepts and techniques.

J. B. AUDEN.

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THE EARTHQUAKES AND THE EARTH (in German) By László Egyed. Translated to German by H. Rast. Publishers: Akadémiai Kiadó, Budapest 1971. Price: Sh. 2.70.

This book has been written by the Hungarian geophysicist Prof. L. Egyed, to explain to an intelligent layman, the geophysical methods used in the study of the interior of the earth with special emphasis on seismology. The book is in the form of a conversation between three people—a doctor of medicine who is curiously interested in the structure of the earth, a geologist as a partner in the discussion, and a geophysicist who answers the questions. There are three chapters in the book. In the first chapter, the general picture of the structure of the interior of the earth starts off from the doubt expressed by the medical man on the existence of Mohorovic discontinuity and the pertinence of the Mohole project. This leads to different geophysical aspects of the crust and interior of the earth, formation of mountains and stratification, faulting, high temperature-high pressure conditions existing inside the earth, and to the ocean floors. It is explained how seismological methods make use of the propagation of the waves caused by earthquakes and artificial explosions. The second chapter is a conversation imagined to be taking-place in the seismological centre at Sashegy (Hungary). The experimental methods and the general principles of the seismograph are explained by the geophysicist The utilitarian aspects of geophysical studies in mineral exploration form the main theme of the third conversation. Oil exploration is cited as a specific example.

The book is only meant to explain some aspects of geophysics particularly seismology, to those who have no idea about the subject. The author has tried to put in different aspects of the basic principles in the form of a conversation and found it difficult to keep up a continuity in thought; but still the rendering of the matter without using the usual mathematical jargon of the subject, kindles the layman's curiosity to know more about the interior of the earth.

G. V. ANANTHA IYER.

PHYSICAL PROCESSES OF SEDIMENTATION. By J. R. L Allen, Earth Science Series I, Edited by J. Sutton and J. V. Watson, London, George Allen and Unwin Ltd., (1970) 248 p. £ 2.50 (in U.K.)

Yet another commendable attempt by this well known author who has written candidly on a topic which is fundamental and vital in a study of clastic rocks. The book examines in a simple manner the way in which the properties of sedimentary deposits depend on the physical behaviour of the moving fluids encountered naturally in the form of winds, rivers, tides and waves.

The book is divided into seven chapters: the physical background to sedimentation; some sedimentary structures, and a note on textures; winds and their deposits; river flow and alluvium; waves, tides, and oceanic circulations; turbidity currents and turbidities; glaciers and glacial deposits. Under each chapter, pertinent topics are discussed; and at the end relevant references to published papers and books are added for extra reading.

Chapter I is an introductory sketch of the physical principles and concepts relevant to the application of fluid dynamics and loose-boundary hydraulics to sedimentation problems of geological interest. It begins with a sketch of the nature of the problem and a statement of Newton's laws of mechanics. Many equations are given in the chapter and apparently each equation is a logical statement in symbols about a real physical situation. Indeed some of the difficulties arise from the unfamiliarity of the language; for not all geologists are, even today, as familiar with mathematical treatment of geological problems as they ought to be.

Chapter II describes 'some sedimentary structures' and largely on the basis of experimental results and observations in modern environments, an attempt is made to outline the role of physics and corresponding processes attending their origin. A brief reference is made to explain the phenomena of sediment sorting and sediment fabric.

The remaining chapters of the book are about the physical processes that are important in different major environments of deposition of terrigenous clastic sediments. Thus, there are four chapters in succession including a detailed treatment of sedimentation, respectively, by wind, by rivers, by waves and tides in shallow water, and by turbidity currents at general depths. The final chapter is about the realm of ice. In his descriptions of 'glacial deposits' the author reproduces a schematic diagram by Reading and Walker to explain subaqueous deposition by 'dry-based' and 'wet-based' glaciers; but, strangely indeed, avoids a reference to the original paper by S. W. Carey and N. Ahmad, nor does he include this important paper in the list of papers cited for extra reading.

Basically the book is meant for undergraduate students of final year, who are studying geology as the main subject. But I personally believe that the book should be useful for graduate students who are beginning a training in research in sedimentation, as well as for professional field geologists if they wish to be familiar with the modern concepts of sedimentation. We have already found use for the book in teaching, and as a reference for research students preparing for work on a topic of sedimentology and sedimentary petrology.

F. AHMAD.

DIAMOND DRILLING. By Chandra Prakash Chugh. Oxford & IBH Publishing Company, New Delhi, Bombay, Calcutta, (1971) pages 484, price Rs. 35.

Diamond drilling is one of the most important tools for the development of mineral industry in any country. This book has been published by a person who has been in the drilling industry for the last twenty years, at a time when we in India are trying to develop our mineral resources. The author has done a very good job in presenting the subject matter in an easy and lucid manner, so that an average reader with elementary knowledge would be able to study it.

Though we have been trying to develop our mineral resources for the last 25 years, the progress has been slow; and also some of the developments which have taken place in the country have not shown the desired results. This has been mainly due to lack of appreciation, understanding, and sparing use of diamond drill. The mineral development in any country or a mine, is judged by the quantum of diamond drilling done every year. Here I would like to cite the example of Japan where the total length of core-drill from surface in 1950 was 28700 metres, whereas the length drilled from the surface in 1969 amounted to 363,000 metres, and from the underground workings 538,000 metres, in metal mines alone. If we add all the drilling done todate in metal mines, we may not reach that figure in India. The drilling efficiency in Japan was improved from 1959 by the introduction of wireline core-barrel.

To support a sustained production of 2 to 3 million tonnes per year, normally the mining companies drill 30 to 40 thousand metres per year from the underground working. The reasons for this much drilling per year are related to the question of time in bringing the deposits into production quickly, and producing desired tonnage and grade on a sustained basis for years to come. If one goes into the history of various mining projects outside our country, one finds that it takes about 4 to 5 years to develop and commission a mining complex from the date of discovery; and it reaches full rated capacity in 3 to 6 months from the date of start. On the contrary, there are not many mining projects in India which have been discovered and brought into full production within a period of 5 to 6 years from the date of discovery, and have kept producing the designed capacity. Therefore, this book will be very useful to all those connected with the development of mineral industry in our country.

The author has gone into minute details in chapters relating to diamond drill, drilling equipment, accesscries and their use. These chapters are well written and easy to read and understand, by an average reader. Besides these, the author has included sections on off-shore drilling, grouting and grout-hole drilling, costing, surveying of drill holes and water requirements for a diamond drilling project. The sections which need elaboration are on the use of wireline core barrel, drilling fluids and muds, wedging, and use of underground drill. The use of muds and drilling fluids can be an effective tool is reducing the cost of core-drilling and deviation of drill holes. Similarly wireline core-barrel is useful in increasing the speed, efficiency and lowering of the costs. These sections, in future, could be suitably revised and would add to the value of the book.

I would recommend this book to geologists, mining engineers, drilling engineers, drill operators and drill manufacturers; and for teaching in the Universities, Engineering colleges, Technical schools and Polytechnics.

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