began in the last years (see *Memoirs Connecticut Ac. of Sciences*, New Haven, Conn.)

(4) History of village communities in Western Tibet in relation to agriculture, and position of prehistoric sites in relation to drainage pattern.

(5) Analysis of water in closed lakes and estimates of rate of flow into such lakes.

The Karewas of Kashmir.*

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THE well-known fact that the fossil remains of sea animals are found on the crest of the Himalayas frequently conveys to the lay mind a picture of mountain tops submerged in an ocean which rose above those heights. Similarly, lake deposits containing the relics of aquatic plants and animals, if found on the elevated slopes of a mountain, might easily convince the uninitiated that a lake must have once existed at that high level.

That this popular fallacy should have invaded the mind of even a modern scientist is the excuse for the present article.

A few days ago my attention was drawn to a report under the heading "*Prehistoric lake near Gulmarg: abundance of fossil plants*" recently published in the *Civil and Military Gazette* of Lahore.[1] Dr. R. R. Stewart of Rawalpindi, an American missionary and botanist, is reported to have expressed the view that there appears to have been "a lake some thousands of years ago at a height of 11,000 feet, just above Gulmarg".

This opinion is evidently based upon the fact, well known to Indian geologists, that lake deposits containing fossil remains, including modern species of aquatic plants and animals, occur on the slopes of the Pir Panjal Range, at altitudes where these species cannot exist to-day.

This brief article will attempt to explain to the general reader the significance of these high-level deposits, known to geologists as the Karewa Series. The Kashmiri name Karewa is applied to the more or less flat terraces or table-lands which cover a great part of the Valley, specially on the left bank of the Jhelum. In places these terraces are found sloping gradually up the mountains on either side of the valley; excellent examples are to be seen from the road between Srinagar and Gulmarg, on the two sides of the Ferozepur Nala, specially below Tangmarg. Recently they have even been traced up in a continuous series as far as the crest of the Pir Panjal Range, which bounds the Kashmir valley on the south-west.

For the information of those not familiar with Kashmir we may say that Gulmarg is a favourite summer resort at about 8,800 ft. altitude on the densely wooded NE slopes of the Pir Panjal Range. These slopes are thickly covered with the old moraines of glaciers which several times during the Pleistocene Ice Age, overran the greater part of Kashmir. Where the moraines are not covered with forest they form extensive undulating meadows, in the Kashmiri language called *marys*, as at Gulmarg, Khilanmarg, Sonemarg, etc. The Pir Panjal Range runs in a NW-SE direction, roughly parallel to the main Himalayan chain which lies east of it. The celebrated Vale of Kashmir, about 84 miles long and 25 miles in its broadest part, lies protected between these snowclad ranges, at a height of about 5,200 to 5,500 feet above sea-level. The river Jhelum issues from springs near the higher SE end of the valley and meanders peacefully through fertile plains to the NW end which is a few hundred feet lower. Here it escapes in rapids through a gorge near Baramula, only ten miles north of Gulmarg in a direct line. See map, Fig. 1.[2]

Ordinarily a casual newspaper report on a scientific matter does not deserve serious notice. But Dr. Stewart has been commissioned by an important scientific body—the Yale North India Expedition (popularly known here as the Karakoram Expedition)—to identify and describe the fossil plants from some of these lake deposits on the slopes of the Pir Panjal. And the conclusion he has arrived at directly conflicts with one of the main scientific results of the Expedition and, in fact, with long established geological evidence.[3]

The fossil-bearing sediments near Gulmarg, like many other deposits of clay, sand and

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* Except for the introductory reference to the press report, this article embodies the substance of an extension lecture delivered at the Punjab University, Lahore, on March 26, 1936.

[1] May 21, 1936, page 5.

[2] This map also illustrates another article in the present volume of *Current Science*, shortly to be published under the title. "*The Himalayan Uplift since the Advent of Man*".

[3] See *e.g.*, Wadia, *Geology of India*, 1926 (Macmillan), pp. 263–264, 383.

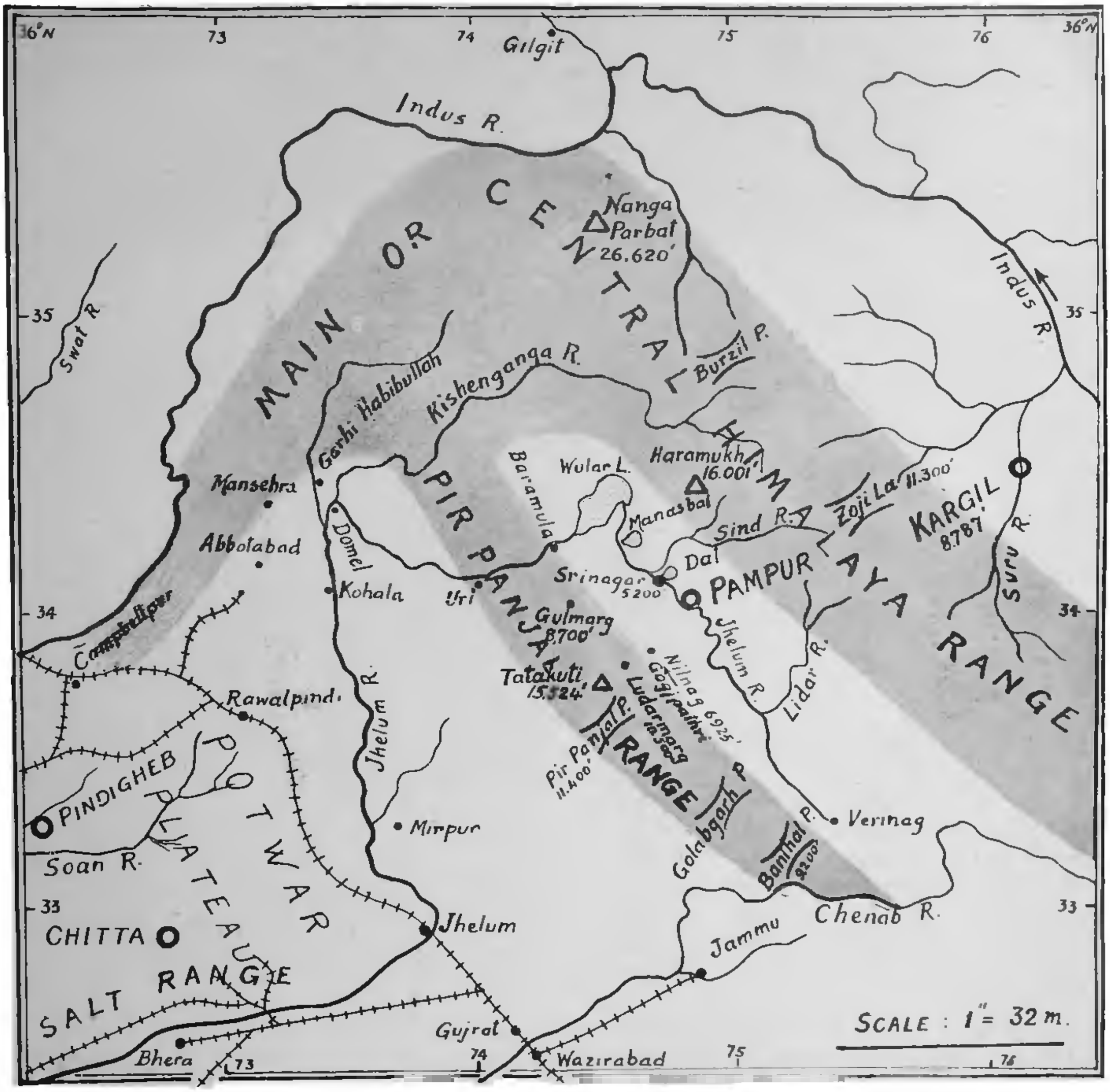

Fig. 1.

gravel on the NE slopes of the Pir Panjal, were no doubt laid down, as Dr. Stewart suggests, in the bed of a lake. *But that lake never existed at the high altitude where its bed is now seen.* Strange though it may seem, this lake must have been situated several thousand feet lower, at the same level as the main valley of Kashmir. Since the time when the plants and animals, of which the fossil remains are now found at 11,000 ft. or even higher, flourished in and around this lake, the sediments have been *lifted out of their original horizontal position* and have been *upheaved through at least five thousand feet with the (geologically speaking) recent upheaval of the Pir Panjal Range.*

The story of these fossil plants from the Pir Panjal Range is briefly as follows. As long ago as 1864, Godwin Austen[4] drew attention to the occurrence of fossil leaves belonging to modern species of plants in clay deposits at Gojipatri (Gogjipatri) near Nilnag, and at Ludarmarg, a meadow about three marches south-east of Gulmarg. Since then fossil plants have been discovered in similar deposits at numerous localities in the Pir Panjal by Middlemiss,[5] Wadia and others.[6] In 1932, Dr. Hellmut de Terra, the

[4] *Quart. Journ. Geol. Soc.*, XX, 383.

[5] *Rec. Geol. Surv. Ind.*, XLI, 120-121, 125 (1911).

[6] Wadia, *loc. cit.*; Sahni, Presid. Addr. to Bot. Sec., Ind. Sci. Congress, Calcutta, *Proc. As. Soc. Beng. (N.S.)*, XVII (1921), clxix-clxx; Wodehouse, "The Pleistocene Pollen of Kashmir," *Mem. Conn. Acad.*, IX, Art. I (1935), 3-18, with Introd. Note by H. de Terra, 1-2. Hawkes, Hawkes and de Terra, Yale North India Expedition: Palæolithic Human Industries in N.W.

leader of the Karakoram Expedition, made a large collection which was presented to the University of Lucknow and entrusted for description to the late Dr. S. K. Mukerji. With his extensive knowledge of the modern flora of Kashmir and, especially, his thorough appreciation of the geological aspects of the problem, Dr. Mukerji was exceptionally well fitted for this investigation. But his premature death in 1934 deprived the expedition of a valued collaborator.[7] Subsequently the entire collection, as well as the notes and preliminary identifications left by him, were on Dr. de Terra's request forwarded to Dr. Stewart, who is now continuing the work of my late colleague.

But before his death, Dr. Mukerji had already arrived at some important results, recently announced by Dr. de Terra[8]. Among the numerous types recognised by Mukerji there were not only land plants (chiefly forest trees and shrubs, such as species of oak, willow, poplar, alder, barberry, rose, rhododendron, cinnamon, holly and box), but also several types of aquatic vegetation, notably the waternut or *singhára* (*Trapa*), *Vallisneria* and stoneworts (*Charophyta*). These aquatic plants still flourish in the Dal, Manasbal and Wular lakes, or in the stagnant backwaters of the Jhelum, far away down in the Valley, several thousand feet lower than the heights at which their fossil remains are now found in the Pir Panjal. So far as we know, they do not exist in any of the numerous lakes, tarns and streams on the higher slopes of the mountains, where the water is either too rushy, or frozen for too long a period in the year. The land plants are rather a mixed lot, mostly represented by species now living on the lower slopes, up to about 9,000 feet; a few, like the rose, have a wide range in altitude, while others grow near the upper limit of tree vegetation.

Let us for the moment confine our attention to the aquatic species which, as stated, live only in the lakes and sluggish streams of the valley. How can we explain the presence of their fossil remains at altitudes where we know they cannot exist to-day? Has the climate of these altitudes become colder since these plants lived; or have these species of plants become acclimatised to the warmer waters of the valley? To the layman, at any rate, these would seem to be the only obvious explanations. But, as we shall see presently, both these views are based upon the unwarranted assumption that the lake (or lakes) existed at the altitudes where their deposits are now seen resting, covered with snow for the greater part of the year.

This is the real point at issue. And its importance will be at once realised when I say that it provides the main proof for the view that a great part of the Pir Panjal Range has been uplifted in quite recent geological times: in fact, as we shall see, since the advent of Man in Kashmir.

The idea that the Pir Panjal Range is largely of recent origin is not new. It was suggested long ago by Godwin Austen in unmistakable terms. Twenty-five years ago Middlemiss[9] advanced further evidence in support of it, while Wadia[10] and several other Indian geologists have repeatedly sponsored this view. The Italian explorers Dainelli[11] and de Filippi[12] also arrived at a similar conclusion. And quite recently de Terra and his co-workers have provided further and more convincing evidence in the same direction.[13] As a slight digression we may add that this recent elevation of the Pir Panjal Range is only a small part of a vast upheaval which has affected the main Himalayan range on the one side and the Potwar plateau (between Rawalpindi and Jhelum) on the other, during the period while Man existed in this part of the world.[14] I propose to deal in a later article with the relation of these recent earth movements to the early history of our own species. Here my main concern is to show that the lacustrine beds near Gulmarg, like a dozen other outcrops in which I have collected fossils in the Gulmarg-Baramula region, were deposited in a low-level lake, where the climate was milder.

Punjab and Kashmir, *Mem. Conn. Acad.*, VIII, esp. Introd. and Geological Commentary by de Terra, i–iv, 11–15.

7 See Obit. Notice in this journal, 1934.

8 See Wodehouse, *loc. cit.*, Introd. Note by de Terra (1935).

9 *Loc cit.*

10 *Loc. cit.* 264, 383.

11 Studi sul glaciale: Spedizione italiana de Filippi nell' Himalaia, ser. 2, III (1922).

12 Himalaya, Karakoram and Eastern Turkestan (1932).

13 See de Terra, Prelim. Report, Yale North India Expedition, *Science*, LXXVII, No. 2004, 497–500 (1933); *Ibid.*, Himalayan and Alpine Orogenies, XVI. International Geolog. Congress, Washington, 1933, p. 9 and literature cited (1934); Hawkes, Hawkes and de Terra, *loc. cit.*; Wodehouse, *loc. cit.*

14 See Wadia, *Mem. Geol. Surv. Ind.*, LI (2), 334 (1928); *Quart. Journ. Geol. Min. Met. Soc. Ind.*, IV (3), 69–96 (1932) and literature cited.

Similar strata, now tilted at angles as high as 30° to 40°, have long been known to occur in the Pir Panjal, sometimes at altitudes even higher than 13,000 feet above the level of the sea; and it is significant that, except for local variations due to other causes, their slope (geologically known as the "dip") is always towards the Valley. What is more, the same deposits have been traced downwards continuously, with gradually decreasing dip, into the valley, where they are seen mostly in their undisturbed horizontal or almost horizontal position (Fig. 2). At one time the valley of Kashmir must have been covered from end to end by these Karewa deposits, which at least 1,000 feet in thickness, which disclose the chequered history of Kashmir during the ages since primitive man first made his appearance here. Below these "Upper Karewas," which contain abundant plant and animal remains of Pleistocene age, as well as Palæolithic stone implements,[15] there is an even greater thickness of older or "Lower Karewas," dating back into Pliocene times. But with these we are not concerned here.

The nature of a stratum, whether fine clay, sand or gravel; its relation with the underlying or overlying strata; and its fossil contents, if any, indicate whether it was deposited in deep water or near a shore, in

Fig. 2.

View looking east from Naugam ridge towards Dodbug (Surv. of Ind. Map 43 J/8). B points to Baramula; V Karewa deposits in Valley (about 5,500 ft. alt.); T Tangmarg (7,000 ft.); G lies below Gulmarg (8,800 ft.). The white bands 1, 2, 3 are Karewa beds exposed in cliff sections. Note the gradual rise of ground from V to T, about 1,500 ft. in 6 miles. *P(B. S. hoto.* 4–7–1934)

either represent the sediments of a single vast body of water or, perhaps more probably, of a series of connected lakes. The existence of Karewa deposits almost as far as the crest of the Panjal Range shows beyond doubt that this lake must have greatly exceeded the present width of the Kashmir valley; and, although at present there is no such evidence, it is by no means unlikely that in places they may be discovered actually overtopping the range and extending to the south-western (that is, the Punjab) slopes of these mountains.

Rain and rivers have cut up the once continuous expanse of Karewas in the Valley into strips and isolated blocks in the form of flat-topped hills. But these remnants still cover nearly half the area of the Valley, and form a conspicuous feature of the landscape. The Karewa at Pampur, celebrated for its saffron fields, is a picturesque example.

Where the vertical thickness of the Karewa Series of deposits is exposed, for example in ravines and gorges, it reveals an imposing succession of strata, totalling stagnant water or in a stream that fed the lake. Its careful study goes a long way to establish conclusions regarding the climatic conditions and the character of the flora and fauna existing at the time of deposition. We know, for example, that in places the Karewa beds rest upon an ancient rock-bottom which shows unmistakable signs of having once been scratched and polished by glaciers, dragging over the old surface their tremendous weight of ice and its contained rock-débris or "moraine". Elsewhere we find fossiliferous clays, containing evidences of life in a temperate climate, such as the shells or skeletons of modern freshwater animals, or the leaves of familiar forest trees, *interbedded with deposits of undoubted glacial origin, indicating arctic conditions.*

Explorers in Kashmir have found that here, as in Europe during the Ice Age, there were several periods of extreme cold when

[15] Hawkes, Hawkes and de Terra, *loc. cit.*, 7, pl. II fig. 3.

glaciers overran even the lower valleys, alternating with relatively warm periods when the ice retreated to the higher regions and allowed the growth of a temperate flora and fauna. And one of the main tasks of the expedition led by Dr. de Terra was to correlate, if possible, the glacial and interglacial periods of northern India with those of Europe. Important conclusions regarding the way in which the plants and animals in this region responded to the changing physical conditions may also be expected from a detailed investigation of the floras and faunas preserved in the different strata of the Karewa Series.

Under the meadowed moraines of Gulmarg itself, which provide such excellent golf links, fossiliferous interglacial clays are exposed at several places in the banks of the meandering brooks. Some of them are almost black with decayed plant-remains; others, of a blue grey colour, are crowded with the shells of fresh-water mollusca, chiefly gasteropods. They remind one of times when this area lay at a considerably lower level and was covered by a lake teeming with animal life. Then came a cold wave, and glaciers from Toshmaidan and from the heights we now know as the Apharwat descended upon the lake, loaded with débris torn from the rocks in their downward path. With the final melting away of the ice the confused mass of sand, clay and angular boulders of various sizes was left behind in mounds, more or less as we find them to-day (Fig. 3). It will interest the reader to know that of the several kinds of fossil shells which I collected from an interglacial bed near the hotel (Fig. 4) at Gulmarg,[16] at least one species is also found

Fig. 3.
Section of re-sorted Moraine at Gulmarg; Apharwat in the background. (*B. S.*)

Fig. 4.
Fossiliferous Interglacial Karewa bed (K) underlying a moraine (M). The topmost layer is Loess Gulmarg, 8,750 ft. (*B. S. Photo, July* 1934)

in the recent alluvium of the river Gomti at Lucknow, where the summer temperatures are all but intolerable.

The Ferozepur Nala just above Tangmarg has cut through a large terminal moraine which must have once almost filled the gorge above the village of Māhiyan. Remnants of this moraine must also be present on the right bank of the stream below Drang. The pony track to Gulmarg traverses the moraine at about 7,500 feet above sea-level, where Mr. Wadia has shown me many good examples of ice-worn boulders. Higher up, the moraine is overlain by lake deposits indicating a return to a warmer climate.

Holiday makers in Kashmir might usefully spend some hours in searching for Palæolithic implements in the "Upper Karewas" of the valley. In the Pampur Karewa near Srinagar, Dr. de Terra recently found several pieces of stone, at least one of which was regarded by experts as "*unmistakably....a humanly-worked flake-implement.*" This important discovery, which no doubt will be followed up by further investigation, tends to show, as Godwin Austen had acutely suggested long ago, that the Himalayan uplift had not yet been completed when man first made his appearance on the globe.[17]

Among the most interesting of the Pleistocene deposits of Kashmir are certain extremely thin layers of alternating fine and coarse clay which were deposited in lakes formed by the damming up of valleys by the terminal moraines of glaciers. They are sometimes so thin that they remind one of

[16] I am indebted to my friend Dr. Baini Pershad of Calcutta for kindly identifying these shells for me.

[17] Hawkes, Hawkes and de Terra, *loc. cit.*, pp. 7, 11, 14; pl. II, fig. 3.

the leaves of a book. These so-called "laminated" clays, technically known as "varves", are very characteristic of glaciated countries. The coarser layers are formed of the heavier sediments brought down by glacier streams during the summer when the ice melts more rapidly; the finer layers represent the winters, when the thin streams fail to carry any but the finest paricles. Each varve, with its summer and winter zones, thus usually indicates a period of one year—unless, of course, in a particular year the seasons have been abnormal, as sometimes happens now-a-days. It is thus possible, by counting up the varves in a given thickness of strata, to calculate with a fair degree of accuracy the total period represented by that deposit in solar years. Such calculations have been used with great advantage by geologists in determining the number of years that have passed since a particular area was glaciated. Thus, for example, the Swedish geologist Baron de Geer has been led to suggest that Stockholm became free from the Ice only about ten thousand years ago.

Apart from the seasonal variation shown by the zones within each varve, Swedish workers led by Prof. de Geer have discovered that long climatic cycles during the geologically recent past are recorded in the varying thickness of the annual varves as a whole. During the warm (interglacial) cycles, when the glaciers were in retreat or were confined only to the higher valleys, each varve often reached the thickness of an inch or more. During the glacial intervals they might not be more than a fraction of a millimetre thick. Taking the relative thickness of the varves as a measure of the heat radiated by the sun, Prof. de Geer and his pupils have been able to correlate the glacial and interglacial periods of Sweden with those of North America; and a similar attempt has been made recently by Dr. E. Norin[18] in Northern Kashmir. Only the preliminary results of Dr. Norin's work have so far been published, and it would be rash to accept them at once as final. But if these promising results should prove to be substantiated by fuller evidence they would go a long way to show that in spite of the long distance between the two countries the glacial and interglacial periods in the Himalayas corresponded with those in the Swedish time scale. This they may well be expected to have done all over the world if they were only due to periodic variations in the amount of solar heat received by the earth.

During excursions in July 1934 I discovered near the hamlet of Hajabal, a few miles north of Gulmarg, a narrow ravine in which a great thickness of light and dark brown varves is beautifully exposed in a cliff section. Similar varves, though much folded by subsequent pressure (perhaps due to the advance of a glacier against them) are well seen at Bota Pathri about five miles WNW of Gulmarg. The counting and measuring of these and other varves in the Karewa Series should lead to important conclusions concerning the history of the Ice Age in Kashmir. The organic remains in the associated fossil-bearing strata, as well as fossils collected in several other localities in this neighbourhood, for example, Tsunt Pathri, Nambil Nar, Dandamuh, Satar Siran, to name only a few, are now being investigated by Dr. S. C. Varma of Lucknow.

There is a well-known tradition in Kashmir, which goes back to time immemorial, that the whole of the Valley was formerly occupied by a lake. This is one of those many traditions relating to the physical features of our country which have been found to fit in with the observed facts of Science. The Dal, the Manasbal, the Wular and many other modern lakes in the Valley of Kashmir are but the shrinking remnants of this great Pleistocene lake on whose shores Palæolithic Man plied his stony trade. Writing as I am from the heights of Gulmarg itself, with the Happy Valley mapped out, as it were, before my feet, I can picture this ancient lake, inhabited by a flora and fauna not very different from that which flourishes to-day in the Manasbal or Wular; and surrounded by wooded hills of no great height except towards the north and east, where lay the main range of the Himalayas. To quote Dr. de Terra himself, "This ancient body of fresh water, known as the Karewa Lake, once filled at least 2,000 square miles of the Kashmir valley. On the north it was flanked by the slope of the main Himalaya and on the south by *a low ridge, now represented by the high Pir Panjal Range, which*

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[18] Norin (1925), Preliminary notes on the late Quaternary glaciation of the NW Himalaya. Data 2, Fr. Stockholms Högskolas Geokronol. Inst., *Geografiska Annaler*, H. 3; Norin (1927), Late glacial clay varves in Himalaya connected with the Swedish time scale. Data 11, *Ibid.*, H. 3.

separated the lake basin from the Indian plains."[19]

The prehistoric lake of which Dr. Stewart speaks may well have been part of the Karewa Lake, and the plants and animals now found as fossils at high altitudes lived in that lake or on the wooded slopes bounding its western shores. The leaves and twigs, fruits and seeds of the forest trees were carried down by streams and became mixed up with the remains of the low level aquatic vegetation buried in the silt of the lake. Apart from these larger fragments of plants, which can be recognised by the unaided eye, the pollen of many species of trees and herbs was also carried down by the water, or was blown down and became sealed up in the clay. Owing to the fact that, like the cuticles of plants, the outer coat of these microscopic pollen grains is very resistant to the natural agents of decay, and because the pollen of many plants is very characteristic, it has been possible for Dr. Wodehouse to recognise several kinds of plants from their pollen grains alone, both in the Karewa deposits and in the silt that is being laid down to-day in the beds of the modern lakes of Kashmir.

Before closing this brief account of the Karewas mention must be made of a widespread deposit of fine yellow or brown sandy earth, known as Loess. In places it forms a mantle several feet thick over the Karewas: it is distinguished by a tendency to form steep slopes or cliffs which are marked by rather charcteristic sinuous rills. The Loess is a deposit of modern times, regarded in origin as wind-borne dust blown over from the plains. Good exposures are to be seen on the golf links at Gulmarg. The Loess has its own importance in the study of human history, but the subject is beyond our present scope.

This is, briefly, the romantic story of the Karewas of Kashmir. Their study leads to the irresistible, though at first incredible, conclusion that the Himalayas have been thrown up by several thousand feet since the advent of man. We may well repeat, in the words of our inspiring teacher of geology, the late Professor T. McKenny Hughes: "Don't be afraid of earth movements, don't be afraid of earth movements"!

GULMARG (Kashmir),
June 13, 1936.

[19] Introd. Note to Wodehouse (1935), *loc. cit.*, p. I. The italics are mine. See also De Terra (1936), Late Cenozoic history in India, *Nature*, **137**, 686–688.

"Indian Science Abstracts".

THE National Institute of Sciences of India, Calcutta, resolved to issue a publication under the title '*Indian Science Abstracts*' with the sub-title '*Being an Annotated Bibliography of Science in India*' every year. The first part of this publication has just been issued, but the General Editor, realising the impossibility of making such a publication complete without the active cooperation of all scientific workers in the country, requests them kindly to look through the 1st Part and see whether all their scientific publications issued during 1935 have been included in it. A great deal of matter for the 2nd Part is already in type, and if all the workers will kindly help by sending abstracts of such of their papers as have not been included in Part I, this will ensure making the record complete for all the scientific publications issued during 1935. *En passant* it may be noted that the publication is intended to include abstracts of all scientific papers published in India, as also of papers published abroad on work done in India or based on Indian material.

The arrangement of abstracts in Part I of the "*Abstracts*" is purely tentative, and any suggestions for making the publication more useful will be gratefully received, and an attempt made to embody, as far as possible, such suggestions in the succeeding parts.

Instructions for the prepartion of abstracts can be obtained from the offices of the National Institute of Sciences of India, 1, Park Street, Calcutta.

Obituary.

WE have to record our profound sense of sorrow at the premature death of Principal Dr. Krishna Kumar Mathur, Principal of the Science College, Benares Hindu University, on July 18th at Lucknow. Dr. K. K. Mathur was one of the foremost geologists of India, who had won the esteem and affection of all his fellow-workers, and had served the Benares Hindu University in various capacities with faithful devotion.