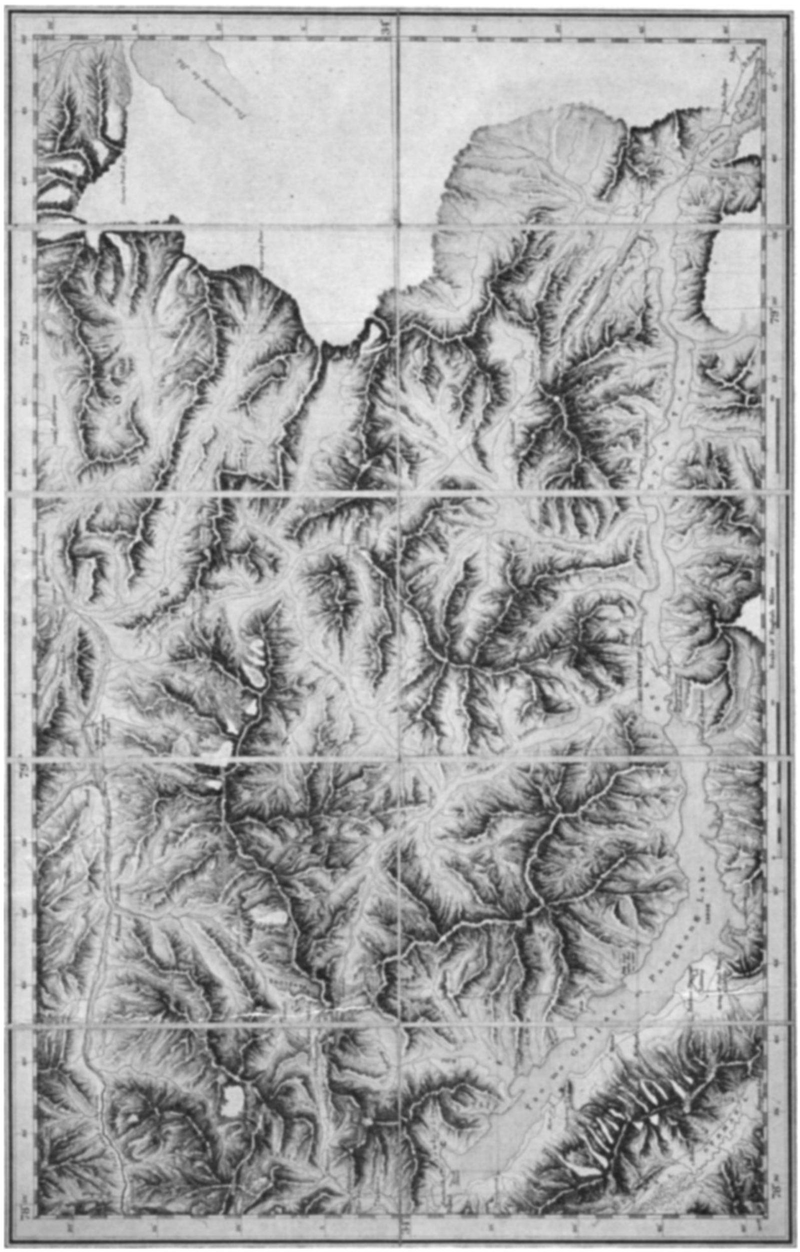
# PANGONG: A GLACIAL LAKE IN THE TIBETAN PLATEAU

ELLSWORTH HUNTINGTON
Milton, Mass.

At the western end of Tibet the Tso-mo-gualari, a series of five connected lakes, lies at an elevation of 14,000 feet in a narrow valley winding for over 100 miles from east to west, among magnificent snowy mountains. The upper lakes, which drain from one to the other and are fresh, lie in Tibetan territory and are but imperfectly known; the lowest and largest lake, Pangong, which has no outlet and is saline, lies in the Indian province of Ladakh or Little Tibet, and is visited almost yearly by British sportsmen. As the two main lakes, Pangong and Nyak Tso, with a combined length of 75 miles, and apparently the others also, lie at nearly the same level and are separated from one another only by an alluvial fan or delta like that at Interlaken in Switzerland, the whole series may be regarded as occupying a single basin with a length of 105 miles, a maximum width of 4 miles, and an average width of only 1.8 miles where covered with water. The basin appears to be due to glacial erosion, and the lakes, as their scenery indicates, belong to the same type as the famous valley lakes of Switzerland. Old moraines show that previous to the formation of the present lake the basin was once or twice filled with ice; while lacustrine deposits and elevated beaches show that in later times the lake-level has fluctuated in response to changes of climate less severe than those which caused the invasion of the basin by glaciers. Thus a record of various phases of the glacial period is preserved in a region where it is especially valuable for purposes of comparison.

While on the way to Chinese Turkestan as a member of the Barrett Expedition to central Asia, I visited Pangong, remaining there from May 1 to May 6, 1905. The lake is exquisitely beautiful, a sparkling sheet of the clearest, deepest blue, shading delicately to purple in the shadows and to pure, pearly green in the shallow rim



MAP OF THE TSO-MO-GUALARI LAKES

near shore. Dark, rugged mountains, especially in the eastern part, spring steeply from smiling blue bays to a height of 1,000 or 2,000 feet (Fig. 1, *A*), and then, at gentler angles, rise 3,000 to 4,000 feet more to a chain of peaks, 20,000 feet high, snow-capped and full of glacier tongues (Fig. 2). Verdure alone is needed to make Pangong rival, or even excel, the most famous lakes of Italy or Switzerland.

In early May, at the time of my visit, the snow had disappeared up to a height of 16,000 feet, and two inches which fell at the level of the lake May 6 melted rapidly. The minimum night temperature ranged from 21° to 29° F. The mornings were sunny and warm, but every afternoon between one and three o'clock a strong west or northwest wind arose, chilly and disagreeable, and sometimes accompanied by squalls of sleet. The scanty bushes and still rarer willow trees had not begun to bud, and the few hardy Buddhists of Tibetan stock (Fig. 3) inhabiting the western shores of the lake were just beginning to sow barley, the only crop which will ripen. Sown in the frosts and snow of May, it is reaped in the frosts and snow of September. At the lake level, 14,000 feet, the barley usually ripens, but at Phobrang, a few hundred feet higher, six miles north of the west end of the lake, the crop often fails, and the upper

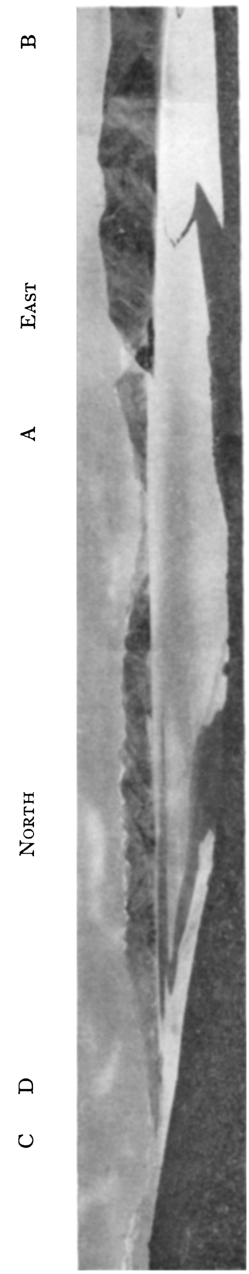



Fig. 1.—Panorama of Lake Pangong from the middle of the south side, May 3, 1905. The west end of the lake had been freed from ice by the wind the previous night, but the narrower and less exposed eastern part remained closed a few days longer.

limit of cultivation is reached not only for this region, but probably for the world.

On May 1 and 2 the lake was entirely covered with pale-green or steel-blue ice, the only exception being some large cracks and a marginal strip 20 to 200 feet wide, where ducks, geese, and gulls fished merrily most of the day, though obliged to sit disconsolate for the first hour or two each morning, when even the open strip was frozen. On the night of May 2 a violent wind blew from the northwest. Next morning, though the temperature was 22° F., the ice had entirely disappeared from the center of the lake for 8 or 10 miles, although the ends were still closed. Part of the ice lay piled along the shore in a ridge 8 or 10 feet high and 30 or 40 wide (Fig. 4). Elsewhere it had been shoved upon the gently sloping beach in large sheets, one of which, from 2 to 4 inches thick, remained unbroken to a size of 15 by 40 feet (Fig. 5). Later I saw a thinner sheet in the act of coming ashore. Un-

FIG. 2.—A little glacier southwest of Lake Pangong, above the village of Man. The latter can be seen on the right lying on an old moraine at the foot of the mountain.

FIG. 3.—A family of Ladakhis living in the outlet valley about 10 miles below Lake Pangong.

der the influence of the usual strong afternoon wind from the northwest, it moved diagonally across the strand at the rate of 3 feet per minute, with as steady a motion as though pushed by an invisible machine. The sandy beach was shoved into a ridge, as appears in the foreground of Fig. 4, and flatstones 8 inches in diameter were easily moved.

FIG. 4.—Ice piled up to a height of 13 feet by the northwest wind on the south shore of Pangong during the night of May 2, 1905. Notice the ridge of gravel shoved up in the foreground.

The quantity of ice thrust upon the beaches did not seem sufficient to account for all of the sudden disappearance. Thinking that a change in the lake's circulation must have been taken place, I resolved to test it by the degree of saltness of the water. On May 1 and 2 I had tasted the latter in the bay east of Mun and elsewhere, and could scarcely detect the least salinity; on May 4 and 5 I tasted it again in the same places, and found it so salt as to be undrinkable. Apparently with the breaking up of the ice under the influence of the wind, currents

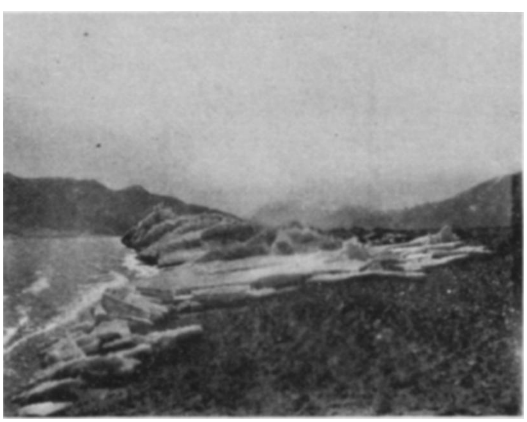


FIG. 5.—Ice on the south shore of Pangong, showing sheets 4 inches thick and 40 feet in diameter shoved up entire.

came into play by which a cold film of fresh surface water, due to melting ice, was displaced by warmer, more saline water from below, and thus the remaining ice was quickly melted.

*Glacial origin of the basin.*—It has been stated by Drew[1] and others that the basin of Pangong is due to the damming of an old outlet by fans from tributary torrents. The old outlet is evident, a broad U-shaped valley extending northwestward from the western end of the lake; and so, too, is the supposed dam, a large fan, 1,500 feet in radius, having its lowest point 90 feet above the lake, and located a mile from the latter at the mouth of a small tributary from the south. The fan forms the divide between the Indus River and Pangong Lake, but it does not appear to have been the cause of the formation of the latter, but rather to have been able to grow up because the

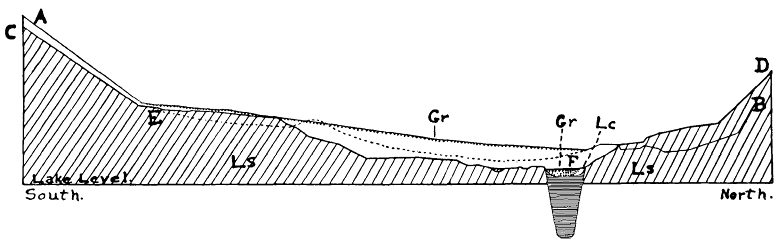



FIG. 6.—Cross-sections of the outlet valley of Lake Pangong drawn to true scale.

*A–L*=section at the fan, at the divide between Lake Pangong and the Indus.
*C–D*=section where the rock lip is most plainly visible.
*E–F*=probable section of the rock below the fan, including a glacial knob.
*Gr*=gravel.
*Lc*=lacustrine deposits.
*Ls*=bed-rock, chiefly marble.

former stream from the Pangong region ceased to flow. The cross-sections of the valley shown in Fig. 6 illustrate the matter. The line *A–B* shows the conditions at the divide, and so far as it alone is concerned, the valley might have been dammed by the fan. The lower section, *C–D*, however, half-way from the divide to the lake, shows quite a different state of affairs. At this point the flat bottom of the broad, steep-sided valley which once served as an outlet is over 600 feet wide; more than 500 feet consists of solid rock, *Ls*, 20 of soft lacrustrine material, *Lc*, and the remaining 90 of gravel, *Gr*, deposited by the insignificant wet-weather tributary flowing from the divide to the lake. Thus the Pangong basin appears to be

[1] F. Drew, *The Jummoo and Kashmir Territories.*

terminated by a rock-lip rising well above the present lake-level. Otherwise there must exist at this point a gorge like that shown in the heavily shaded portion of the section. Its depth must be equal to at least the height of the lowest point of the section above the lake, 35 feet, plus the depth of the lake which Drew (p. 323) gives as 142 feet, that is a total of 177 feet. Its width at the top cannot be over 110 feet. Such a gorge is quite out of harmony with the topography of the outlet valley and of the other valleys of the region, and there is no reason to suppose that it exists.

Furthermore, supposing for the moment that such a gorge existed, it could scarcely have been dammed by the fan of the insignificant little wet-weather stream at the divide. If there were no lake, the outlet stream would be large and swift, for it would consist of (1) the Lamle and Lukung brooks, each of which was large, even in May before the flood season; (2) the stream at Ote from the upper lakes, described by Rawling[1] as a river 60 feet wide and 15 feet deep, with a current of $1\frac{1}{2}$ miles per hour; and (3) a host of minor streams. It is almost safe to say categorically that, even if the climate were drier than now, the floods from the whole Pangong basin, when united into a single stream at the bottom of such an extremely deep, narrow gorge, could not be dammed by the fan of a single tributary, one of the smallest. This is shown by the condition of the old outlet valley below the divide. On either side numerous tributary torrents have formed fans as large as those at the divide; yet even the small wet-weather torrent which here occupies the valley has succeeded in keeping its channel open. To be sure, the stream has been caused to aggrade behind each fan, and at Tso Tsear, 3 miles from the divide, a small lake has actually been formed which overflows with every flood. This, however, is where no water flows permanently and where the drainage area is measured by tens instead of thousands of square miles. Three miles below Tso Tsear, just above Muglib, the permanent stream begins. Though small at first, probably not a tenth as large as the supposed Pangong stream, it has had no difficulty in keeping open a broad channel through fans as large as that at the divide. In view of all the facts, it seems extremely improbable

[1] C. G. Rawling, "Exploration of Western Tibet and Rudok," *Geographical Journal*, Vol. XXV, p. 428.

that there is any narrow inner gorge at the divide, and still more improbable that one of the smallest tributaries, joining the main stream in the gorge where the latter would be most powerful, could completely dam it, especially as the fans of other larger tributaries have produced no such effect. If it be supposed that the outlet has been dammed by a moraine instead of by a fan, it is still necessary to assume the existence of the same improbable gorge, and to explain how such a gorge could ever come to exist. It is further necessary to assume the existence of a completely concealed moraine, for in this part of the outlet valley there is no trace of any such thing, although glacial knobs show that ice once filled it, depositing moraines lower down. The theory of a dam, whether due to a fan or to a moraine, seems untenable. The only alternative is that the Pangong basin is closed by a rock-lip.

FIG. 7.—Glacial knobs in the mouth of the Pangong outlet valley near Tonktse. Glacial smoothing is clearly seen on the left where the fort *A* stands on a completely isolated, well-striated knob.

The most satisfactory explanation of the formation of the lip seems to be that the basin behind it has been glacially eroded. Another possibility is that the lip is due to warping or faulting, but this may be dismissed for lack of evidence. There is no sign of recent faulting in this region, nor of warping of the kind demanded. As is evident from the map, the long, winding basin occupied by Pangong and the other lakes is distinctly a river valley, with no affinity to the type of basin due to crustal movements. Of glacial action, on the other hand, there is abundant evidence, not only near the lake, but down-stream in the outlet valley. Below Tanktse, 20 miles from the lake, an old moraine from 500 to 1,000 feet thick extends 5 miles down-stream. The characteristic topography has been destroyed and the moraine is smoothed and terraced, but the typical structure remains. Above Tanktse, in the mouth of the outlet valley, finely polished knobs of schist and gneiss (*A*, Fig. 7) show that a glacier came down the valley from Pangong and doubtless deposited part of the moraine, though more may have come from the broader Chumik valley on the south. The knobs and the smoothly glaciated valley bottom are covered in part by a deposit of cobbles and huge bowlders, apparently a moraine laid down in the presence of running water. From analogy with other regions, it is probable that the deposit represents a second advance of the ice, but it may represent merely a stage in the retreat of the first glacier. Farther up the valley, at the tiny lake of Tso Tsear, other glacial knobs appear, and the irregularities in the valley floor shown in the cross-sections of the divide and of the rock-lip in Fig. 6 are of the same sort. It is clear that for 30 miles from Pangong to Dugrukh the outlet valley has been occupied once or twice by glaciers descending below the level of the lake.

FIG. 8.—A deep re-entrant at the northwest end of Lake Pangong. View from an elevation of 1,000 feet looking southeast across the lake at the line of glaciers and moraines on the farther side.

Around the lake itself there are further evidences of glacial action. In the Lukung valley, at the west end of Pangong, a large moraine lies 2 or 3 miles north of the mouth of the outlet valley. Along the southwest shore of the lake something like twenty small glaciers peep out from the tops of the mountains (Figs. 2 and 8), and formerly at times of greater extension deposited moraines well down toward the lake. All these, however, belong to comparatively recent times when, apparently, no moraines reached the basin floor and it was occupied by a lake. The proof of an earlier, more extensive glaciation lies first in the oversteepened lower slopes of the mountains already referred to in describing the appearance of the lake, and second in numerous erratic bowlders of granite perched on slopes and ridges of schist or of metamorphic sedimentary rocks (Fig. 9). The bowlders vary in size from 1 to 25 feet in diameter, and are found at all elevations up to at least 600 feet above the lake. They occur on both sides of the latter, and on almost every slope facing toward it or toward the outlet. The greatest accumulations are found in small protected valleys such as those marked *A*, *B*, and *C* on the map. The granite bowlders can have been brought to their present position on the schist only by a glacier large enough to fill the whole Pangong basin.

The glacier did not come to an end at the rock-lip, as might be expected, but, as we have already seen, continued on for 20 or 30 miles as a comparatively narrow tongue giving rise to the U-shape of the outlet valley, and to the glacial knobs already described, and leaving at least one hanging valley with its mouth 200 feet above the flat valley floor on the south side near the little lake of Tso Tsear. If the Pangong basin is due to glacial erosion, it is necessary to explain why in what once was a single uniform valley the part above the lip has been widened ten times as much as the part below, and deepened correspondingly. Rock structure and texture have something to do with the matter, for there is a hard stratum of marble at the lip; but, except for this, the difference between the schists and metamorphic sedimentaries above and below the lip seem insufficient to account for so marked a contrast. It is possible that the Lukung glacier from the north meeting the Pangong glacier from the southeast acted as a check upon the latter, causing it to broaden and deepen its channel up-stream instead of down. Another possibility is that a glacier or glaciers of smaller size previous to the maximum glacier may have reached only to the lip, broadening the valley above, but not below. When the maximum glacier advanced, the constriction of the valley at the lip would allow only a narrow tongue to extend forward and would cause broadening and deepening of the channel upward.

There is still doubt as to the possibility of the excavation of basins by glaciers. The Pangong basin offers nothing new by which the question can be answered, but it is significant because it adds another to the examples where a peculiar type of basin is associated with glaciation among lofty mountains. The essential features of the Pangong basin agree with those of the fiords of Norway and the valley lakes of Switzerland and other places. The finding of so perfect an example of the type on the edge of the Tibetan plateau, where the theory of glacial erosion would lead us to expect it, lends probability to the theory. The rarity of such lakes among the Himalayas seems to be due to the fact that most of the valleys slope steeply and uniformly and have no portions of gentle grade where the glaciers would be checked and caused to deepen their beds.

*Pangong during later glacial epochs.*—The history of Pangong after the completion of the rock basin is recorded chiefly in lacustrine deposits and shore-lines, which, together with numerous old moraines, indicate two extremes of moisture, or at least of lake and glacier expansion intervening between extremes of aridity or of lake and glacier contraction. At the mouth of the little tributary whose fan has been wrongly supposed to be the cause of the accumulation of the waters of Pangong, there are some narrow terraces, remnants of an older, larger fan. The latter must have been formed after the retreat of the last great basin-scouring glacier, and at a time so arid that the main stream was not large enough to carry away the débris brought in by the tributary. If the fan were to be reconstructed from its fragments, it would fill the outlet valley to a depth of 200 feet, more or less; that is, to approximately the level of the highest of the strands presently to be described. As the deposits associated with these strands are saline, it appears that at the time of the accumulation of the fan the lake had no outlet, and hence that the epoch was arid, perhaps as arid as the present.

On the approach of the next glacial epoch the glaciers on the sides of the Pangong basin descended several thousand feet, as is evident from the moraines which they deposited a few hundred or a thousand feet above the lake. The latter must have expanded and finally overflowed, for it cut away the fan across the lip, as may be inferred from the terraced remnants. Before overflowing, however, it must, while still saline, have stood at a level of nearly 200 feet long enough to deposit a thin layer of calcareous sinter. The latter occurs on an isolated hill of schist east of Tukkung in the middle of the south side of the lake (Fig 9 *A*), and again on a marble spur in the outlet valley close to the lip. It forms a thin coating on the surface of rocks which had been well smoothed and rounded by the previous glaciation. At the same level there are other evidences of the high stand of the lake. In a general view from almost any point a distinct line can be seen at a height of about 200 feet above the present strand wherever the lake shores consist of solid rock, as appears at the right of Fig. 1. In most places it is a mere scratch, indistinguishable close at hand, though visible in a general view; elsewhere it forms a slight notch, or even a very insignificant bench and bluff. Below it, in favorable locations, two or three still fainter lines appear upon the steep rocky shores. The parallelism of the lines to one another and to the present strand, their continuity around the lake, and their utter disregard of the structure of the rocks on which they lie, make it practically certain that they are strands marking former short-lived high levels of the lake.

FIG. 9.—The lower set of beaches in a cove in the middle of the south side of Lake Pangong. The bowlder in the foreground, 12 feet in diameter, consists of granite. It was brought by a glacier to its present position on a slope of schist 200 feet above the lake.

When the lines are followed into some of the minor ravines where erosion proceeds slowly, this conclusion is supported. Here, at a height of about 200 feet, there are a number of little fans hung upon the side of the mountain as though they had been deposited when the water stood much higher than now, and nipped off into terraces in front as though the water had retired step by step. Such terraced fans, like the one at *B* on the extreme right of Fig. 1, may be seen along the southwest side of the lake on the steep shores between Spangmik and the outlet, on the promontory east of Man, and in the first deep bay east of Tukkung. An allied phenomenon is found in certain well-defined benches contouring around the isolated hills or knobs which lie in the vicinity of Tukkung, and probably represent the line of weak erosion between the main Pangong glacier and the large Lamle tributary. The panorama of the lake (Fig. 1) was taken from one of the knobs which itself is seen in Fig. 9 (*A*) as a flat-topped promontory. In the panorama two knobs may be seen (*C* and *D*), both of which were islands when the lake stood at the higher levels. The benches are best developed on the sides of the farther and larger knob (*C*), which lies about a mile

FIG. 10.—View to the north from an isolated glacier knob near Tukkung, showing the older and the younger set of beaches.

west of the mouth of the Lamle brook. They are cut in the soft, thick talus of the schistose rock, and, as appears in Fig. 10, have clearly the form of strands. In the photograph five benches appear. In reality there are six or possibly seven, lying at subequal intervals between 90 and 210 feet above the lake. Below them, in the right-hand portion of the photograph, still other strands appear, which, however, are much younger and will be considered later. Putting together the evidence of the dissected fan at the outlet, the deposits of sinter up to a height of 200 feet, the faint strand-lines cut in the solid rock, the fragmentary terraced fans, and the benches about the isolated knobs, the history of the lake at this time seems fairly well defined. After the retirement of the last of the basin-making glaciers a dry epoch ensued, during which a salt lake filled the basin, standing at a low level long enough to allow the accumulation of a fan above the rock-lip. Then, presumably upon the advent of a glacial epoch, the lake rose until at a height of 200 feet above the present level it began to overflow across the fan. From that time onward the water fell, pausing but a short time at each of the levels where the six or seven faint strands appear. One reason for the fall in the lake-level was doubtless the cutting away of the fan at the outlet, but as the latter appears to have been of uniform texture, this will not account for the fluctuations in the rate of fall as indicated by the strands. Another reason was the gradual desiccation which, as is shown below, finally reduced the lake to its last low level previous to that of today. The desiccation probably proceeded at a fluctuating rate, as we shall see to have been the case in a still later epoch, and the terraces and strands may be attributed to this.

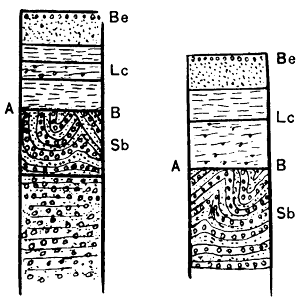


FIG. 11.—Sections of the fan at Tukkung.
*A*, *B*=Unconformity.
*Be*=Gravel beach.
*Lc*=Lacustrine deposits.
*Sb*=Subaerial (fluvial) deposits.

Evidence of the low level reached by the lake after the formation of the strands just described is found in the present fan at the outlet and in the deposits exposed in cuttings made by streams in other fans along the lake shore. In the outlet valley, as we have already seen, the older fan was cut away during a glacial epoch. The present fan could not have accumulated unless the outlet stream was greatly reduced in size or ceased to flow; that is, unless the climate became somewhat arid. More conclusive evidence of the low strand of the lake is found at Tukkung, along the Lamle brook, where the two sections illustrated in Fig. 11 lie about 100 yards apart, their tops being about 20 feet above the present lake-level. The deposits above the unconformity (*A–B*) consist of lacustrine marls, more or less saline, containing fossil shells and plants; while those below are fluviatile deposits of sand and gravel like that which the stream now carries. The folding and crumpling to which the gravels have been subjected is like that which is today produced on the beach when ice is blown ashore. The lake deposits continue for long distances and clearly belong to the time of the lake's latest expansion. Farther west on the side of a small stream between Man and Meruk the same features are exposed even more clearly in the section of which Fig. 12 is a photograph. The top of the section stands 30 feet above the lake, which lies several hundred


FIG. 12.—Photograph of the bank of a stream near Man, showing features like those of Fig. 11, especially beach gravels broken and tilted by ice and later covered by the deposits of a rising lake.

yards to the right or north of the observer. The succession of strata from the top downward is as follows:

*Be*
- 2 feet, fine beach-gravel, and cobbles deposited by the lake in its last retreat.
- 4 feet, sandy clay, presumably a shore deposit.
- 1 foot, fine gravel, presumably a shore deposit.

*Lc*
- 3 feet, finely banded lacrustine clay.
- 1 foot, white saline marl with lacustrine shells.

Unconformity.

*Sb* 10 feet, subaerial sands and gravels crumpled by ice.

Apparently after the fall in the lake indicated by the strands described in the preceding paragraph, the water reached a level so low that subaerial fans were deposited only 20 or 30 feet above the strand of today and possibly still lower. Then the lake rose. At first its ice crumpled the sub-aerial deposits on the lake shore, but later, as the water rose higher, it planed off their surface and deposited upon them locustrine clays and marls.

If the stream whose banks are illustrated in Fig. 12 be followed upward, a section is found like that shown in Fig. 13, which is typical of the southwest side of the lake. The large moraines (3) belonging to the first glacial epoch after the retreat of the ice from the main Pangong basin form a ridge from 100 to 1,000 feet above the lake. In one of them a valley has been dissected and has been filled with ordinary schistose talus (*T*) from a ridge near by. The talus passes gradually into the subaerial sands and gravels (*Sb*) of the lower parts of the sections described in the preceding paragraph. The next deposit is a layer of lacustrine clays (*Lc*), lying on a smooth, wave-swept surface. On top of all lies a series of beaches (*B*) formed by the lake in the course of its last contraction. Moraine 3

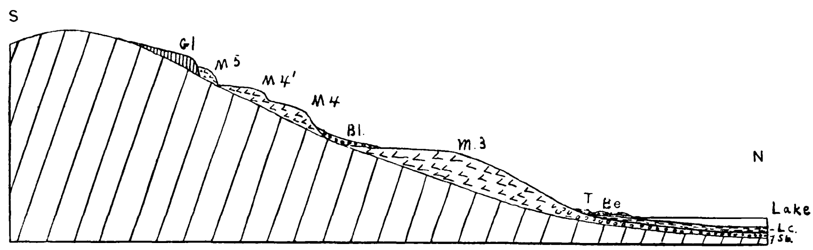



FIG. 13.—Cross-section from Lake Pangong to the summit of the mountains on the south shore of the lake near Man.

*Be* = Beaches. *Lc* = Lacustrine deposits.
*Bl* = Bowlders. *M 3, 4, 5* = Moraines.
*Gl* = Glacier. *Sb* = Subaerial fluvial deposits.
*T* = Talus.

appears to be synchronous with the 200-foot lake, and to have been dissected during the succeeding interglacial epoch when the lake stood as low or lower than at present. The moraines 4 and 4′, intermediate in size and age between the present moraine, 5, and the older moraine, 3, are apparently synchronous with the last expansion of the lake, when it rose 60 feet above the present level, crumpling the beach by means of drifting ice and depositing the lacustrine strata *Lc* of the last three sections.

The evidence of this last rise and fall of the lake is very abundant, and has been described by Drew and others. From a height of

60 feet downward the entire lake is bordered by a succession of old strands (see Figs. 9, and 10). The mean levels of the most important strands, as measured in eight sections distributed for 25 miles along the southwest, west, and north shores, were at the following heights above the level of the water in May, 1905, when it was said to be about 3 feet below flood-level: namely, 7, 14, 22, 33, 43, and 61 feet. The strands vary in character in the normal fashion, being marked by beaches in the bays and by cliffs and benches along the headlands. They appear to be of very recent date, this being especially noticeable where they are cut in soft, young fans and are still preserved almost unmarred, even though talus is being poured rapidly upon them. Along the headlands the upper benches are usually cut in a rather hard conglomerate or breccia composed of beach pebbles

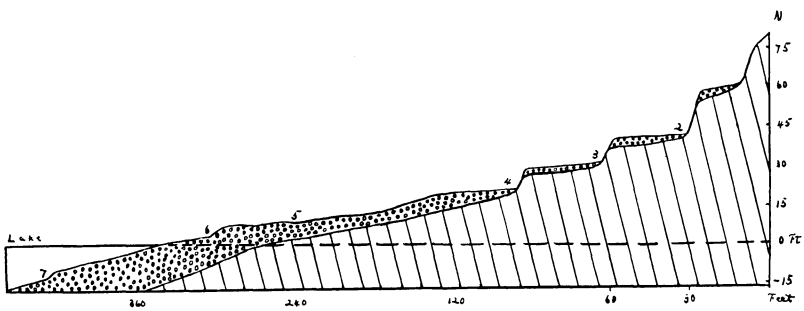



FIG. 14.—Recent lake beaches at the northwest end of Lake Pangong. Drawn to true scale.

and talus cemented by white saline, or calcareous sinter, the deposit of the enlarged lake. In a few especially exposed situations the benches have been cut in solid rock, as illustrated in Fig. 14. The lake seems to have stood longest at the higher levels, since at these it did the greatest amount of cutting. It appears to have had no outlet at any time during its last expansion, for the fan at the lip shows no sign of having been recently dissected (see Fig. 6 *A*, *B*), and its lowest part stands 30 feet above the highest strand. Apparently the fall of the lake and all the accompanying irregularities whereby the beaches were formed are due entirely to desiccation.

Some light on the nature of the process of desiccation may be gained from Fig. 15, which illustrates a section exposed in the same fan where Figs. 11 and 12 were seen. From below upward along the line *xy* the section is as follows:

*A*. ½ foot of fine gravel with sand beneath it, the two forming parts of an old subaerial fan or of a beach.

*B*. 1 foot of lacustrine clay deposited by the lake during its expansion to the 60-foot level and continuing as an uninterrupted band to a height of 50 feet above the lake.

*C*. 3 feet of shingle deposited on a beach at a time when the lake must have retired.

*D*. 1 foot of lacustrine clay soon thinning out away from the lake, but thickening toward it and joining *B*.

*E*. 5 feet of shingle deposited on a beach.

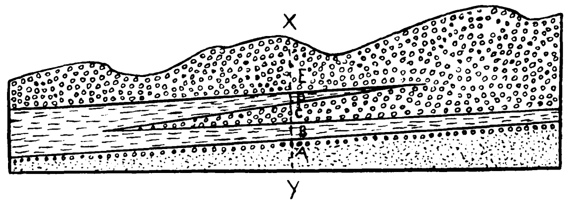



FIG. 15.—Section of lacustrine and shore deposits showing alternating rise and fall of the lake.

The section can be interpreted only on the supposition that in its fall from the 60-foot level the lake fell while *C* was being deposited, remaining at a level of less than 40 feet long enough for the formation of a shingle beach 3 or more feet thick. It then rose 10 feet or more, remaining high until a foot of fine clay had been deposited, and finally fell again, forming the beaches which now lie on the surface. A similar oscillation has occurred still more recently on a smaller scale. At several points along the lake-shore, especially at the northwest corner, three or four little beaches can be seen in the water down to a depth of 12 feet, more or less. The head man of the village of Spangmik said that when he was a boy, some 20 or 30 years ago, the water was 10 or 12 feet lower than now, although in his grandfather's time it stood higher than now. Possibly the submerged beaches, which are very slight, were formed at this time of low water not more than thirty years ago. Whatever their date may be, it is evident that the beaches, like the deposits of Fig. 15, indicate that the lake is subject to constant oscillations due to variations either in rainfall or evaporation. Apparently the process of desiccation has not been continuous in the fashion illustrated by the line *A*, Fig. 16, nor has it been interrupted merely by periods of rest, as shown in *B*, but rather it has been oscillatory, like *C*, now drier, now wetter, but the tendency to aridity generally greater than its opponent. The changes appear to be of precisely the same nature as the much larger changes which characterize the glacial period with its alternating glacial and interglacial epochs. If the oscillations are merely local, their study is of comparatively small importance; but if, as there is reason to believe, corresponding variations are taking place simultaneously over vast areas, they demand the closest study. There seems to be nothing except size to differentiate them from glacial epochs, and as they are even now in progress, their study can be carried on at close hand, and may perhaps be helpful, not only in solving the secret of the cause of the glacial period, but of the part played by climate throughout the whole course of geological history.

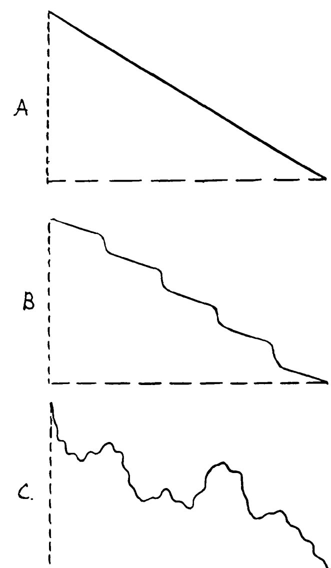



FIG. 16.—Diagram to illustrate the course of dessication at Pangong. The horizontal ordinate represents time, and the vertical the condition of climate, wetter or colder upward, drier or warmer downward.