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A century of investigations on outbursts of the ice-dammed lake Merzbacher (central Tien Shan)

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Abstract

Bavarian alpinist and researcher Gottfried Merzbacher discovered an ice-dammed lake in 1903 while trying to reach the mysterious Khan Tengri peak, located where Kyrgyzstan, Kazakhstan, and China meet. This lake, which was later named after him, is currently two lakes in the Northern Inylchek Valley. At an altitude of 3300 m and 3400 m above sea level (a.s.l.), these two lakes are known as Lower Lake Merzbacher and Upper Lake Merzbacher. Lower Lake Merzbacher is dammed by the Southern Inylchek Glacier and has had regular outbursts since the beginning of the 20th century. While these outbursts have been sporadically documented since 1902, neither the documentation nor the reliability of the reports has been consistent. Knowledge of many of the floods is known only from the oral or written contributions of mountaineers, glaciologists, and frontier guards. A small number of floods were measured at gauging stations downstream. Since it was not always recognized that these floods were the results of glacier lake outbursts, not many papers on this subject have been published in German, English or Russian journals. There were about 40 outbursts reported between 1902 and 2004, but only a few of them were eye witnessed. A number of geoscientific expeditions investigated glacier retreat and the mechanism of the (lower) lake's outburst through an englacial piping system of the Southern Inylchek Glacier. As the Inylchek River flows into the Tarim Basin, the flood waves endanger not only Kyrgyzstan but also China. This paper gives a short overview on the mechanism, magnitude, repetition rate and timing of Lake Merzbacher's outbursts. Of particular interest is the discovery that the outbursts have shifted statistically significantly, namely from September/October in the first half of the century to July/August in last few decades. It is presumed that this is due to the climate change. Future research on the impact of climate change on the Upper Inylchek Valley is supported by the Global Change Observatory "Gottfried Merzbacher", which opened in 2009 and was jointly planned by the Central Institute of Applied Geosciences (CAIAG, Bishkek, Kyrgyz Republic) and the German Research Center Potsdam (GeoForschungsZentrum – GFZ-Potsdam, Germany). The installation of ablation gauges, planned ice core drilling, and hydrometeorologic and seismologic stations will make it possible to assess the climatic and neotectonic development of the Central Tien Shan in general and to calculate the mass balance and quantification of the partly retreating Southern Inylchek Glacier in particular. This article "A Century of Investigations on Outbursts of the Ice-Dammed Lake Merzbacher" briefly summarizes observations and research conducted since 1903 and also documents the lake's regular outbursts.

Als der bayerische Forscher und Alpinist Gottfried Merzbacher im Jahre 1903 versuchte den im Grenzgebiet zwischen Kyrgyzstan, Kazachstan und China gelegenen Khan Tengri (7439 m SH) zu erreichen, entdeckte er einen eisgedämmten See, der später nach ihm benannt wurde. Da heute im Nördlichen Inylchek Tal jedoch zwei Seen existieren, wird der niedrigere, auf 3300 m Seehöhe gelegene, als Unterer- und der höhere auf 3400 m Seehöhe als Oberer Merzbacher See bezeichnet. Der Untere Merzbacher See wird durch den Südlichen Inylchek Gletscher aufgestaut und bricht regelmäßig seit Beginn des 20. Jahrhunderts aus. Viele Ereignisse von Flutwellen im Inylchek sind durch Erzählungen oder Reiseberichte von Alpinisten, Glaziologen und Grenzposten überliefert. Nur wenige Hochwässer wurden in Abfluss-Stationen gemessen und mit Gletscherseeausbrüchen in Zusammenhang gebracht, so dass nur wenige Arbeiten in deutschsprachigen, englischen und russischen Fachzeitschriften publiziert worden sind. Seit Beginn des 20. Jahrhunderts sind so etwa 40 Ausbrüche dokumentiert, aber nur wenige wurden direkt beobachtet. Zahlreiche geowissenschaftliche Expeditionen untersuchten den Gletscherrückzug und den Ausbruchsmechanismus des (Unteren) Merzbacher Sees durch ein englaziales Röhrensystem des Südlichen Inylchek Gletschers. Da der Inylchek weiter nach Süden ins Tarim Becken fließt, führen die Hochwasserwellen der Gletscherseeausbrüche nicht nur zu Überflutungen in Ost-Kirgistan sondern auch in China. Die Arbeit über ein Jahrhundert Erforschung der Gletscherseeausbrüche des Merzbacher Sees gibt einen kurzen Überblick über den Mechanismus, die Wassermengen, Wiederholungsrate und Ausbruchszeitpunkt des Merzbacher Gletschersees. Besonders interessant erscheint die Auswertung, dass sich der Ausbruchszeitpunkt statistisch stark verschoben hat, nämlich von September/Oktober in der ersten Hälfte des vorigen Jahrhunderts zu Juli/August in den vergangenen Jahrzehnten. Vermutet wird, dass dieser Trend ganz allgemein auf den Klimawandel zurückzuführen ist. Künftige Forschungsarbeiten über die Folgewirkungen der Klimaveränderungen im Oberen Inylchek Tal werden durch das Global Change Observatorium „Gottfried Merzbacher" unterstützt, das gemeinsam vom Zentralinstitut für Angewandte Geowissenschaften (CAIAG, Bishkek, Kyrgyzstan) und dem GeoForschungsZentrum Potsdam geplant und im Sommer 2009 eröffnet worden ist. Die geplante Einrichtung automatischer Schnee-Ablationsmessgeräte sowie permanenter hydrometeorologischer und seismischer Stationen wird wertvolle Beiträge für die klimatologische und

neotektonische Entwicklung des zentralen Tien Shan im allgemeinen und die Berechnung der Massenbilanz des teilweise im Rückzug befindlichen Südlichen Inylchek Gletschers im Speziellen liefern. Im vorliegenden Aufsatz "A Century of Investigations on Outbursts of the Ice-Dammed Lake Merzbacher" werden erstmalig die seit 1903 durchgeführten umfangreichen Forschungsarbeiten sowie die regelmäßigen Ausbrüche des Merzbacher Sees dokumentiert.

1. Introduction

Lake Merzbacher is located in the remote Inylchek Region in the very heart of the central Tien Shan mountain range, close to Khan Tengri (6995 m) and Pobeda Peak (7439 m), the highest summit at the Chinese border. This lake was accidentally discovered by the German explorer, cartographer and alpinist Gottfried Merzbacher (1843-1926) during his expedition in 1903, when it hindered his team from reaching Khan Tengri along the route passing the northern Inylchek Glacier. The findings of his expeditions were published under the authority of the Royal Geographical Society (Merzbacher, 1905). A less detailed report was also published in an Austrian journal (Merzbacher, 1906).

2. Description of lake Merzbacher

Gottfried Merzbacher discovered the lake in the summer of 1903 and, despite the fact that his measurements of the altitude were too high compared to present data, his description was vivid: "…an attempt was now made to penetrate up the northern branch of the glacier. Where the middle range divides the enormous ice-field it is very uneven, and unusually crevassed, owing to compression against the cliffs. The crossing was difficult, and when at last we approached the entrance of the northern glacial valley, we found ourselves suddenly confronted by a wide depression, ... It stood at a level of about 11,800 ft (3,600 m.), and was filled with an icy lake, in whose blue waters floated thousands of tiny icebergs and frozen blocks in every shape and form – altogether a magnificent sight." (Merzbacher, 1905, p. 200).

Although he did not publish a picture of this lake, he described the size of the glacier dammed lake in detail as follows: "The lake stretches for about two and a half miles (four versts) into the northern branch of the glacier, which here averages three-quarters of a mile in breadth, and would probably have offered no further obstacles to the passage over its surface, owing to the northerly bend of the southern flank of the valley, here, too, no view could be had of Khan-Tengri." (Merzbacher, 1905, p. 201). Converting the distances to kilometers (1 verst equals 1,0668 km, 1 mile equals 1,71 km), the size of the lake is approximately 4 km by 1,28 km in this paper.

Russian alpinist Michail Pogrebetskij, who headed another expedition in 1931 (Pogrebetskij, 1935), named the lake after Dr. Gottfried Merzbacher, who has been granted an honorary doctorate by the Philosophical Faculty of Munich University. It should be noted that Gottfried Merzbacher was the very first European to reach the head of the Inylchek Glacier, which is one of the largest continental glaciers in the world. He also

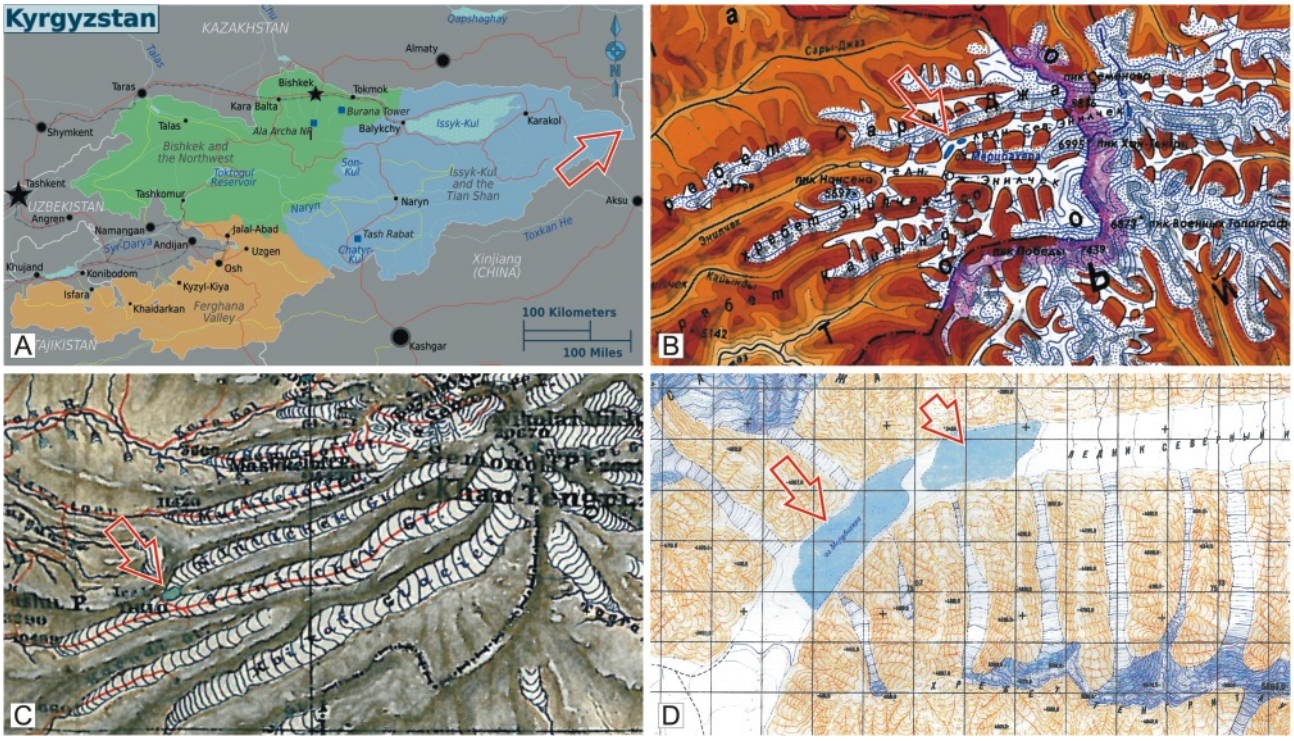

Figure 1: Lake Merzbacher is located in the east of the Kyrgyz Republic (A). Topographic map of the Kyrgyz Republic at original scale 1:500.000 (B). The local situation of the lake as mapped by G. Merzbacher (1905; C) and in the Soviet map from 1957 at original scale 1:100.000 (D). The position of the lake is indicated by the long arrow.

enhanced the Russian maps of this region. The remoteness and difficulty of access to the Central Tien Shan region, the turbulences of the First World War, and later on the stormy political events in Russia were among the reasons that new information on expeditions to Lake Merzbacher was for a long time only acquired from Soviet mountaineers who climbed the grandiose peaks of this region. They mentioned the Lake in their books and papers (see Table 1 and references).

Gottfried Merzbacher (1905, p. 200 f.) describes: "The lake extends for three-quarters of a mile across to the opposite bank... The lake was found to be enclosed on both sides by precipitous rocky walls, about 3,900 ft (1,200 m.) high, which descend close to the water's edge. Attempts were made both on the north and south side to clamber round these walls, and thus to turn the lake, but all in vain. The lake stretches for about two and a half miles (four versts) into the northern branch of the glacier, which here averages three quarters of a mile in breath." Merzbacher's original goal was to identify the true position of Khan-Tengri, which was at that time considered the highest mountain in the central Tien Shan range. Based on these descriptions and the enhanced Russian 40 versts map with a scale of 1:1,680.000 the glacier-dammed lake was located at the confluence between the northern and southern Inylchek Glacier at an altitude of about 3100 m. However, the early photographs of the bending Southern Inylchek Glacier as published by Merzbacher (1905; 1906) did not show the lake itself.

Presently, two lakes exist in the Northern Inylchek Valley. These are known as "Lower Lake Merzbacher" and "Upper Lake Merzbacher", and are separated by an area termed "Peremitschka", which means "the area between the lakes". Before these lakes came to exist, the Northern Inylchek Glacier joined the Southern Inylchek Glacier approximately where the Global Change Observatory Central Asia "Gottfried Merzbacher" is currently located. When the first expeditions were faced with this lake at the beginning of the 20th century, there was only one major lake (the lower lake) dammed by the Southern Inylchek Glacier (Figure 1).

On the occasion of the international expedition Inylchek 2005, a memorial plaque was situated opposite Lake Merzbacher, where the Global Observatory "Gottfried Merzbacher" was constructed in 2009. The Observatory enables monitoring climate change of the Central Tien Shan in general, and geohazards in the Upper Inylchek Valley induced by climate change in particular (Figure 2).

It is likely that the "initial" lake, as detected by Gottfried Merzbacher in 1903, came to exist when the front of the Northern Inylchek Glacier melted and the proglacial lake was dammed by the Southern Inylchek Glacier. This likely happened in the second half of the 19th century (Glazirin and Popov, 1999). A further retreat of the Northern Inylchek Glacier caused a second proglacial lake to appear at it's terminus in the middle of 20th century. This lake was later named "Upper Lake Merzbacher". Its initial stage is visible in Figure 1D above the Lower Lake as indicated by the short arrow.

A comparison of the topographic maps of the early 1940's and 1960's reveals that Upper Lake Merzbacher grew to approximately the size of Lower Lake Merzbacher. According to Mavlyudov (1999), the upper lake was destroyed by a surge of the Northern Inylchek Glacier in 1997 when its glacier tongue advanced approximately four kilometers. This surge was likely not an exception. Pogrebetskij interpreted the surface of the Northern Inylchek Glacier as the result of a surging glacier in 1929 (Pogrebetskij, 1949), and Bakov & Dianmin (1995) again compared the geomorphology of the Northern Inylchek Glacier with a glacier surge.

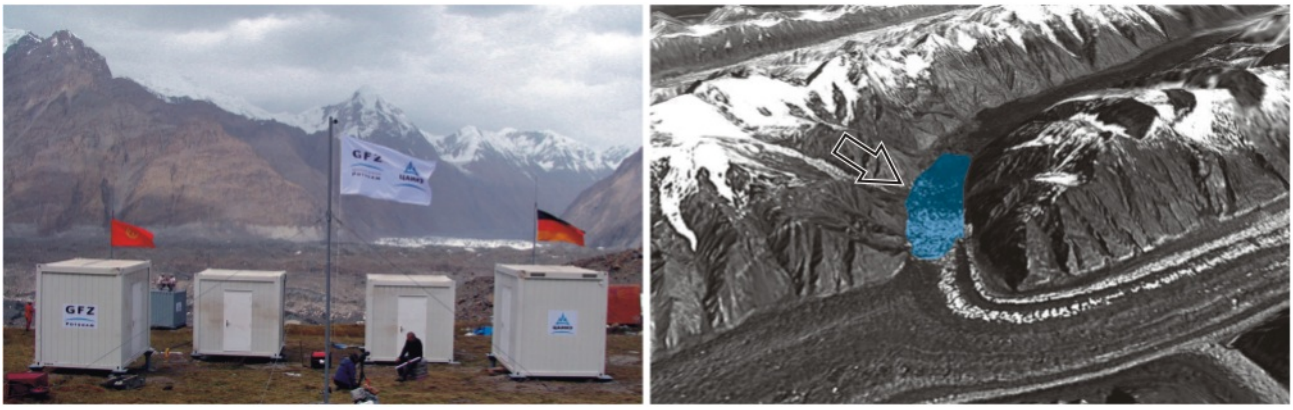

Figure 2: The Global Change Observatory "Gottfried Merzbacher" (Wetzel, 2009; left) is located south of the former confluence of the Northern and Southern Inylchek Glacier. Lower Lake Merzbacher (indicated by arrow; partly covered by floating icebergs) came into existence after the retreat of the Northern Inylchek Glacier (Google Earth; right).

Currently, Lower Lake Merzbacher is approximately four square kilometers in size. When the lake has been filled up with melting water from the Northern Inylchek Valley, its maximum depth close to the damming Southern Inylchek Glacier is about 100 m. For reasons not fully understood, the lake releases its entire volume almost every year. Numerous ice blocks floating on its surface are formed by icebergs calving from the Southern Inylchek Glacier and from small side glaciers hanging

above the lake. After the total discharge of Lake Merzbacher in late summer, these icebergs sink to the lake bottom and freeze to ground during the winter. As Lake Merzbacher fills up again in the summer, these icebergs sometimes rapidly "jump" to the lake surface, producing a high spray fountain (Ryzhov, 1959). As documented in the reference list, many Soviet and Russian scientists have investigated the phenomenon of Lake Merzbacher.

What follows is a summary of Lake Merzbacher's regular outbursts and the consequent glacier lake outburst floods. The history of the visits to study the lake can be divided into several stages (Table 1). Here it can be seen that the studies became more and more detailed and the emphasis was changed from simple descriptions of the lake to research of the lake surroundings, the lake bottom and the hydrologic regime.

3. Hydrological regime of the lake

Lakes dammed by glaciers are known worldwide, and lakes developing in front of glaciers are termed "proglacial" lakes. Proglacial lakes can also be formed in front of surging glaciers, as in the Karakorum Mountains, the Tien Shan Mountains, and Alaska, to name a few. Usually, such proglacial lakes either enlarge until the glacier totally retreats, or are short-lived and disappear after their outburst. The repeated fill of a proglacial lake dammed by the major glacier stream, as documented for Lake Merzbacher over the last 100 years, is an exception (Vinogradov, 1977). The release is a component of the annual hydrological cycle of the lake regime. Basically, the process can be described as follows: In the summer, melt water (predominantly from the Northern Inylchek Valley) fills up Lake Merzbacher. Ajrapet'yants and Bakov (1971 b) observed that the water level of Lake Merzbacher increased about 2 meters per day during periods of intense ice melting. After filling, the lake bursts out.

The reasons for the lake's release remained a mystery for a long time. Although Thorarinsson analyzed the phenomenon at the end of the 1930's (Vinogradov, 1977), decades passed until Soviet scientists found a hypothesis for the regular release of Lake Merzbacher (Ajrapet'yants & Bakov, 1971 b). The release of the lake water begins when the ice dam of the advancing Southern Inylchek Glacier buoys upwards. As a consequence, a system of englacial channels in the damming glacier opens and the lake water discharges through the main Inylchek Glacier westwards into the Inylchek Valley.

It is very significant that the instant of the channel system opening is by accident. This explains the different water volumes, the unreliable forecasts of outbursts using data on lake filling are unreliable, and why a release can occur twice in a single year. Once the englacial channels start opening, they quickly increase in diameter because of the kinetic energy and slightly higher temperature of the water flow. After the lake has emptied, the ice dam lowers, the englacial channels are

Year	Research activity
1903	Gottfried Merzbacher discovered the lake by chance during his expedition to Khan -Tengri (Merzbacher, 1905)
1912	Geodetic and topographic work of Russian military topographers in Central Tien Shan. However, survey groups did not reach the Inylchek Valley, and the topographic map of the Upper Inylchek region was significantly improved during the topographic survey in 1943.
1928-1938	Annual expeditions of mountaineers to Southern and Northern Inylchek Glaciers for climbing to Khan - Tengri and other peaks of the region. Evidence for regular lake outbursts almost every year resulting in big flash floods along the Inylchek River (e.g.: Demchenko, 1934; Gusev, 1949; Pogrebetskij, 1935; Ryzhov, 1959; Zhavzharov, 1935; etc.).
1943	Topographic survey of the area and aerial reconnaissance flights of the region: discovery of Pobeda Peak and evaluation of its height at 7439 m. Significant improvement of topographic maps (e.g.: Zabirov, 1947; Avsyuk, 1950; Ratsek, 1954).
1955	First simple glaciological measurements near the lake.
1971	Explanation of lake outburst process (Ajrapet'yants & Bakov, 1971 b).
1976	Simulation of flood hydrograph (Glazirin & Sokolov, 1976; Vinogradov, 1977; Glazirin & Kagan, 1986).
1984	First mapping of the lake bottom using aerial photographs from reconnaissance flights in 1943 and 1981 (Kuzmichenok, 1984).
1971-1990	Attempts at predicting the timing of lake outburst (Sokolov & Leonova, 1981; Konovalov, 1990).
1990	Geophysical measurements of depth of the Inylchek Glacier in the vicinity of the lake (Macheret et al., 1993).
1995-1999	Investigation of the geometry of the lake bottom, the englacial caverns, and regime of the Northern Inylchek Glacier (Mavlyudov, 1995-1999).
2005-present	Investigation of the lake area using GPS and other methods by German, Austrian and Kyrgyz scientists in 2005 (Helm et al., 2008; Mayer et al., 2008) and 2009 (Häusler et al., 2010).

Table 1: A century of glaciological research at Lake Merzbacher.

blocked, and the lake begins to fill again. A careful survey and radio echo sounding by Ajrapet'yants and Bakov (1971 a), and Macheret et al. (1993) revealed a complex laminated structure of the Southern Inylchek Glacier in the vicinity of the lake. Therefore, a higher permeability can be assumed along the borders of these layers. Bulat Mavlyudov recently revealed (Mavlyudov, 1999) that there is a permanent small outflow from the lake. A higher permeability at the bottom of the lake could – at least locally – be interpreted as a layer of alluvial deposits permanently draining the base flow of the Northern Inylchek Valley.

Flood water from the lake enters the Inylchek River, then leaves for China and is not used in Kyrgyzstan. This is why no long-term hydrologic observations on the river were performed. A gauging station ("Inylchek Mouth") not far from mouth of the river was only operational for a total of 6 years (1962-1965, 1980-1981) and was unfortunately cancelled after 1981. The station was situated about 50 km from the glacier.

Figure 3 shows unpublished data from the Inylchek Mouth gauging station. Four of the graphs are hydrographs, and the other two of 1966 and 1980 show the change in water level. It should be noted that two floods were recorded in 1980.

The gauging station measured the base flow of the Inylchek River during the summer (i.e. July-August) in 1963 and 1964 at about 100 m^3/s (Figure 3). Both of these years recorded September flood events with 750 m^3/s and 500 m^3/s respectively. 1980 and 1981 are both examples of years with two floods each. In 1980, the first flood occurred in mid-May and the second flood at the beginning of September, both floods reaching a height of 600 cm (probably equaling 700 m^3/s). The early event in 1980 may be due to the fact that the lake was not entirely filled in autumn 1979, and therefore it released the water in spring 1980. During the following three months Lake Merzbacher probably filled up again and burst once more at the beginning of September. In 1981, the major event (up to 700 m^3/s) occurred in early July, whereas the second flood occurred two months later, albeit with a reduced discharge of only 250 m^3/s. The flood plain of the Inylchek River below the Inylchek Glacier has a width up to 1.5 kilometers for a distance of 25-30 kilometers, and caused a significant spreading of the flood wave. Therefore the maximum discharge of an outburst from Lake Merzbacher can be assessed as much higher com-

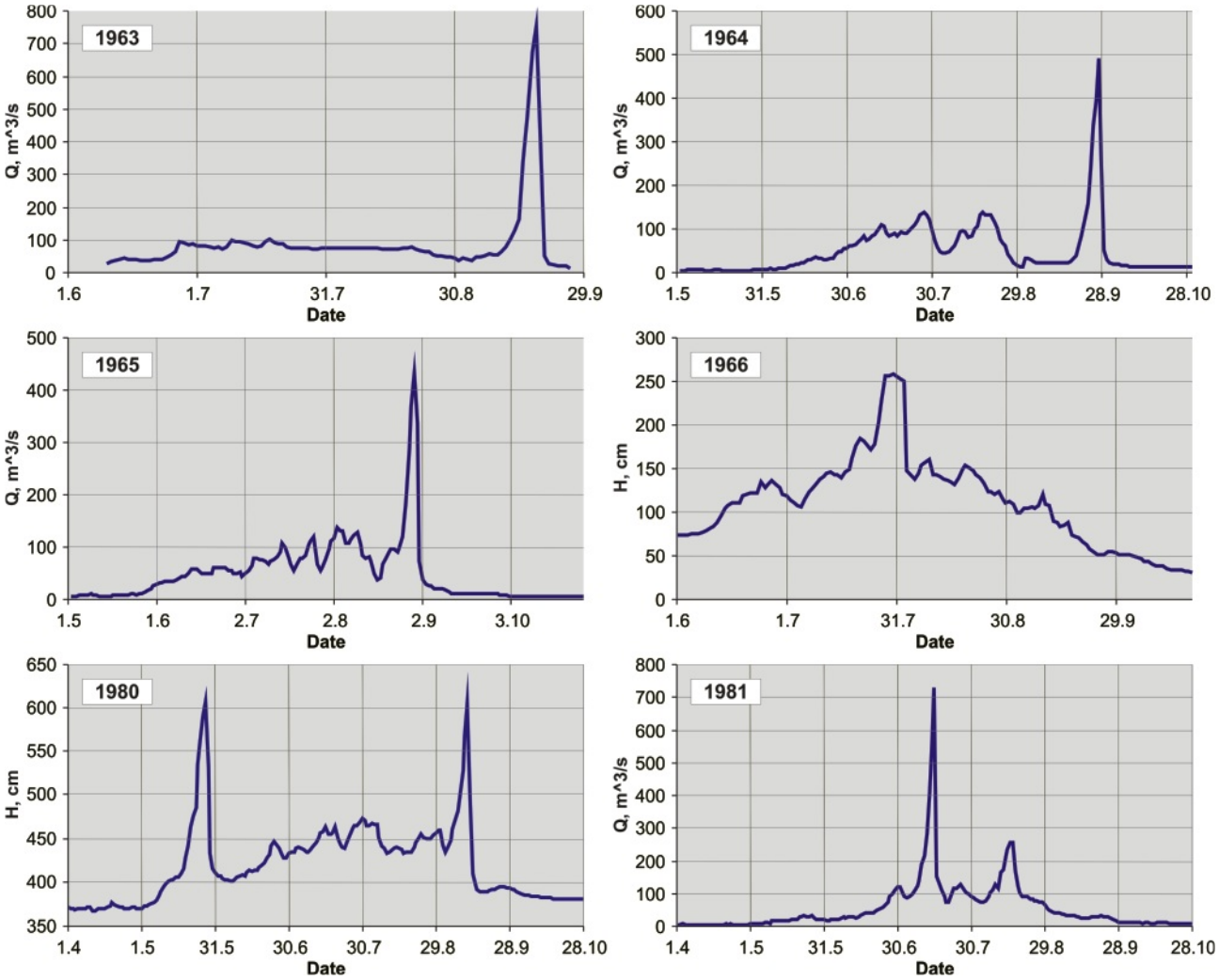

Figure 3: Discharge of Inylchek River measured at the gauging station "Inylchek Mouth". Hydrograph (Water discharge: Q in m^3/s) is calculated for 1963-1965, and 1981, and height of water level (H in cm) is shown for the 1966 and 1980. x-achses give calendar dates (day.month).

Year	Date	Source
1902	August, between 21 and 31	Merzbacher, 1906
1931	September, 18-19	Ryzhov, 1959
1932	September, 8-12	Pogrebetskij, 1935
1933	August, between 21 and 31	Glazirin and Kagan, 1986
1935	Sep., between 1 and 10	Glazirin and Kagan, 1986
1936	October, between 1 and 10	Glazirin and Kagan, 1986
1937	October, between 1 and 10	Glazirin and Kagan, 1986
1938	October, between 21 and 31	Glazirin and Kagan, 1986
1939	August, 1	Ajrapet'yants and Bakov, 1971
1940	October, between 11 and 20	Glazirin and Kagan, 1986
1941	October, between 1 and 10	Glazirin and Kagan, 1986
1942	October, between 1 and 10	Glazirin and Kagan, 1986
1943	September, 22	Glazirin and Kagan, 1986
1949	August, 1-3	Ajrapet'yants and Bakov, 1971
1954	August, 24	Ajrapet'yants and Bakov, 1971
1956	September, 2	Ajrapet'yants and Bakov, 1971
1957	July, 25; August, 31	Glazirin and Kagan, 1986
1958	September, between 1 and 10	Glazirin and Kagan, 1986
1959	August, 26	Glazirin and Kagan, 1986
1960	July, 22; September, 4	Glazirin and Kagan, 1986
1961	September, 9	Ajrapet'yants and Bakov, 1971
1962	September, 15	Hydrological Year Book
1963	September, 7-9	Hydrological Year Book
1964	September, 16	Hydrological Year Book
1965	August, 16	Hydrological Year Book
1966	July, 4; December, 27	Ajrapet'yants and Bakov, 1971
1967	September, 7	Ajrapet'yants and Bakov, 1971
1970	September, 1	Glazirin and Kagan, 1986
1978	September, between 1 and 10	Glazirin and Kagan, 1986
1979	No outburst	Glazirin and Kagan, 1986
1980	May, 15; September, 2	Hydrological Year Book
1981	July, 8; August, 8	Hydrological Year Book
1982	August, 14	Konovalov, 1990
1984	August, 20	Konovalov, 1990
1985	August, 9	Konovalov, 1990
1986	August, 26	Konovalov, 1990
1987	August, 14	Konovalov, 1990
1989	October, 10	Mavlyudov, 1996
1990	August, 5	Mavlyudov, 1996
2001	July, 27-28	Oral documentation
2002	August, 1-2	Oral documentation
2003	July, 22-23	Oral documentation
2004	August, 6-7	Oral documentation
2005	July, 13-15	Oral documentation

Table 2: Outburst dates of Lake Merzbacher, and approximate duration of flooding of Inylchek River.

pared to the hydrograph measurement at the Inylchek Mouth gauging station.

4. Long term records of the lake outbursts

Traces of the first outburst were fixed by Merzbacher himself. According to his description, we can conclude that Gottfried Merzbacher himself eye witnessed a glacier lake outburst flood in 1902 (the year before he reached the lake himself). He saw huge ice blocks in the Inylchek Valley downstream from the glacier, and supposed them to have split off the glacier tongue. He wrote (Merzbacher, 1905, p. 72): "Even so late as the end of August in the year 1902, and at a distance of two miles from the glacier, I came upon several blocks of ice as big as a house in the boulder-strewn Inylchek valley, exposed though it is to such extreme insolation." The sudden released and unexpected high amount of water can be explained by the outburst of a lake which Gottfried Merzbacher had not yet discovered in 1902. As a heavy earthquake on the morning of August 22nd 1902 caused huge ice falls close to their camp at Tuz Aschu pass (Merzbacher, 1905, p. 71), this earthquake may also have triggered this early outburst of nearby Lake Merzbacher.

The data on the timing of other outbursts is based on different sources such as scientific publications (Zabirov & Bakov, 1981; Glazirin & Kagan, 1986; Konovalov, 1990; etc.) and data from downstream gauging stations, but mainly on oral or written contributions from mountaineers, glaciologists, and frontier guards. It must be mentioned, however, that the various sources sometimes differ in their dates. All collected dates are shown in Table 2.

Figure 4 shows the timing of Lake Merzbacher's outbursts over a century. The graph reveals that outbursts have tended to occur earlier in the year since the 1930's, statistically shifting from October to August. There

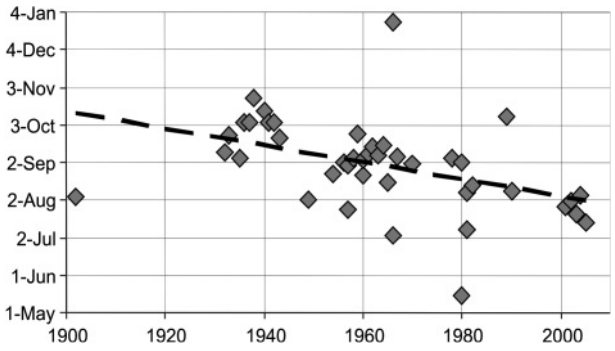

Figure 4: Long-term record of outburst dates from Lake Merzbacher. Data from the Table 2 are used.

are two potential reasons for this fact: firstly, the gradual increase of summer air temperatures in high mountain regions results in an increase of ice-and snow melting and thus accelerates the filling of Lake Merzbacher with melted water. Secondly, the Southern Inylchek Glacier became thinner due to down wasting caused by regional warming. The damming ice barrier of the still advancing part of the Southern Inylchek Glacier therefore melted faster and released the water of Lake Merzbacher earlier. Perhaps both factors contribute to the present situation of the general retreat of the Southern Inylchek Glacier, which only partly is also advancing.

As the Inylchek River flows to the Saryjas River which then flows to China, a very important source for hydrological data on glacier lake outburst floods from the upper catchments is provided by hydrological observation along the Aksu (Kunmalike) River in the Tarim River Basin (Liu Jinshi, 1992). Data has been collected at the Xiehela gauging station since 1956. The station is located approximately 200 km southward of the terminus of the Southern Inylchek Glacier and about 150 km south of the confluence of the Inylchek River and the Saryjas River. Floods from an outburst of Lake Merzbacher were measured at both the Inylchek Mouth and Xiehela gauging stations. This data is very useful because a comparison of 8 maximal discharge dates (for those years where both gauging stations were working) shows that the peak of the flood reached the lower station less than one day after passing the Inylchek Mouth gauging station. In other years, however, when the only information was from incidental eye-witnesses, the difference between the peak of the flood passing the Inylchek Mouth and Xiehela gauging stations was sometimes much larger. This can be explained twofold. First, travelers at the glacier usually remembered the start of the outburst, whereas the Chinese papers listed the dates of maximal discharge. Second, eye-witness information is usually transferred via several persons and therefore errors may have occurred with regard to dating the outburst.

5. Conclusion

This paper described the history of the investigation of the very interesting remote and hard-to-access ice-dammed Lake Merzbacher. All data on its outbursts collected by scientists, mountaineers, and travelers was shown. Its fate is controlled by the drastic shrinkage of glaciers caused by regional climate change. We hope that future investigation of the lake will clarify some aspects of its unusual activity.

Acknowledgments

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References

Adding the Russian references facilitates finding the original literature in international libraries, which is often not possible when only the English transliteration of the title and the journal are provided. Despite the recent UN recommendation for the romanization of the Russian alphabet (GOST-83), the editorial team of the AJES tolerates the transliterations below because these English citations have been used in Russian and Anglo-American literature during the last century.

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