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PRELIMINARY STUDY ON FLASH FLOODS IN TARIM RIVER BASIN

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ABSTRACT: Flash floods are the important events of the hydrological regime of rivers in arid areas. In the Tarim River, northwestern China, flash floods are being monitored. The observed data and investigation demonstrate the difference in time, place, frequency and intensity of their occurrences. In this paper two main flash floods are put forward, they are rainstorm flash flood (RFF) and glacier lake outburst flood (GLOF). Two cases of flash flood in the two tributaries of the Tarim River presented in this paper. It analyses and compares the causes and the development of the two kinds of flash floods. Through further discussion about influence of flash floods on the main channel of the Tarim River, conclusion can be drawn that the greatest flood in record of the main channel come from the GLOF of the upper reaches of the Kunmalik River, especially augmented by great ablation flood. Finally the advantages and disadvantages from flash floods to the environment of the catchment are demonstrated in the paper.
KEY WORDS: flash floods, rainstorm flash flood, glacier lake outburst flood, Tarim River basin

Flash floods are the important events of the hydrological regime of rivers in arid areas. In the Tarim River (Fig. 1), northwestern China, flash floods are being monitored. The observed data and investigation demonstrate the difference in time, place, frequency and intensity of their occurrences.

There are three types of floods common to the Tarim River basin. Almost every year high water occurs in monthes of July, August and September caused by ablation runoff. However, the most damaging flows are from occasional flash floods by instense rainstorm and glacier lake outburst flood(GLOF) respectively in the tributaries of the river. Among them, the rainstorm flash flood(RFF) in 1971 and GLOF in 1984 were significant flash floods.

I. SYNOPSIS OF EVENT

1. July 7,1971 in Aksu River

The flood occurred on July 7, 1971. It was due to one intense storm from July 5 to 7 cov-

ering almost whole area of western South Xinjiang. The total rainfall in the central area (Tailan Station) was 110 mm, in Aksu it was 82 mm. The area that the rainfall was more than 50 mm was about 30,000 km^2, covering 70% of the total catchment area of the Aksu River, and the maximum rainfall in an hour was 8 mm by record (Zhang, 1987).

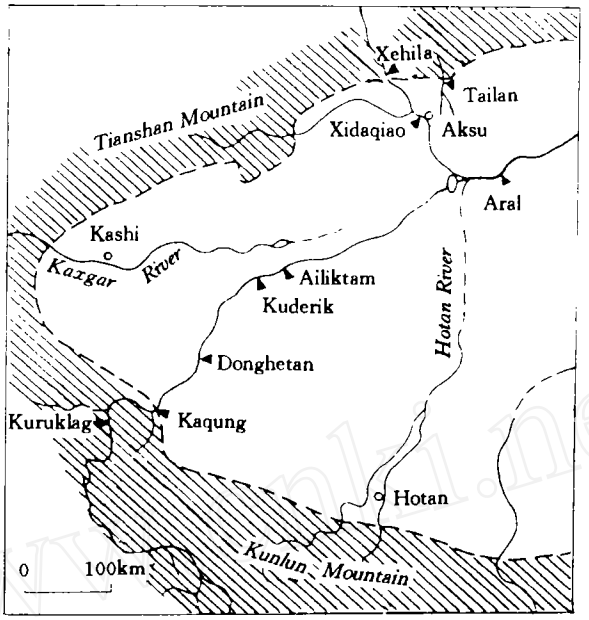

Fig. 1 Sketch map of tributaries of Tarim River and hydrological guiding stations

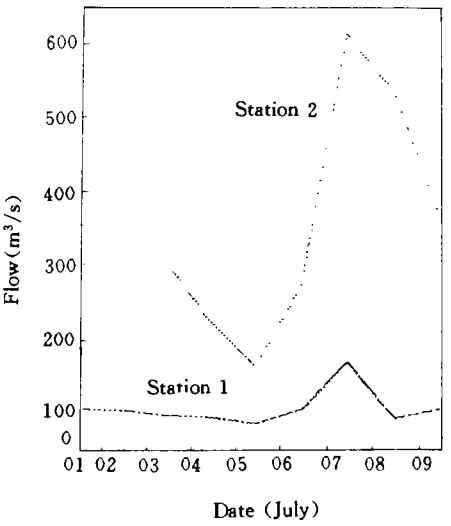

Fig. 2 Discharge in Station 1 and Station 2

The procedure of rainstorm started from the west part of the Tarim River basin in July 5, getting stronger in Aksu area then toward northeast. It sustained 46 hours from 10:00 of 5th to 7:08 of 7th in Aksu. The maximum precipitation in Gauging Station 1 and Gauging Station 2 was 74.1 mm and 41.9 mm respectively, and it was 47% and 71% of their annual precipitation respectively.

Because the middle or low intense rainfall of February and March before the rainstorm added the humiduty to the soil, the following precipitation resulted in surface runoff in the most part. As a result the rivers in this area flash floods occurred although they had different peak discharges (Fig. 2). Gauging Station 1 recorded the instant maximum peak discharge of 191 m^3/s at 10:00 of July 7 in the Tailan River, and the discharge was the greatest in the same year. Its frequency of occurrence was 50%. In Gauging Station 2 the maximum peak discharge of 654 m^3/s passed through, which can be classified as moderate flood of the river.

2. GLOF in Yarkant River in August 1984

The Yarkant River is a tributary of the Tarim River, its flow is mainly from ablation runoff. Almost every year there are floods in the river. However, the most damaging floods occasionally occurred with the characteristics of swift and violent, high peak and amount (Table 1).

Table 1 Annual maximum flood peak discharge of Kaqung Station (m^3/s)

Year	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Peak discharge	1300	6270	1300	1690	2450	1770	1550	1560	3150	1330
Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Peak discharge	1000	4570	1270	2220	1650	1340	1520	2670	4700	1960
Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Peak discharge	1300	1550	1600	1560	4570	1410	1980	1840	1670	1560

Table 1 shows that in general years their maximum flood discharge is 1000 – 2000 m^3/s, however, the floods with the discharge over 4000 m^3/s even to 6270 m^3/s occurred 4 times during 34 years. Fig. 3 shows hydrological process two types of floods.

The flood of August 1984 was from sudden sluicing dewatering of glacier dammed lake located in the upper reaches of the Keleqing River, which is a tributary of the Yarkant River (Zhang, 1990). It was estimated that the peak discharge at the end of glacier lake was about 10480 m^3/s, and the relation of peak discharge to total flood discharge in Kacqung Hydrological Station is described as:

$$Q_m = 1.7\ W_m^{0.97} (r = 0.92)$$

where: Q_m is peak discharge, W_m is total flood amount, r is correlation coefficient (Zhang, 1990)

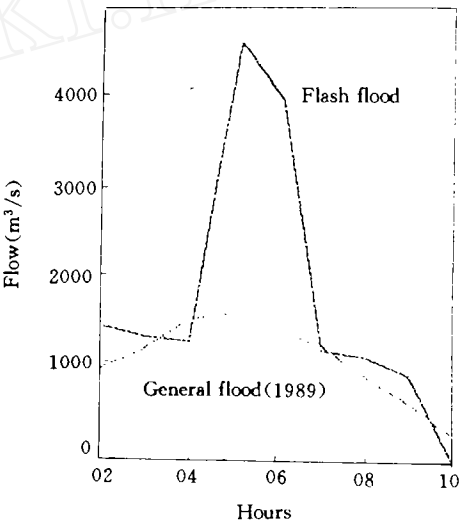

Fig. 3 Hydrological processes of flash and general floods at Kaqung

Water level at Kaqung Station severely fluctuated on 30 th: at 22:00 it was 7.73m, after only 20 minutes it rapidly rose to 9.48m. The big fluctuation in water level destroyed the rule that ablation flood has daily fluctuation.

II. COMPARISONS AND ANALYSIS

Occurrence cause of RFF in the Tarim River basin is simple. Rainstorm floods correspond with rainstorm amount, scope, duration, intensity and type. In the upper reaches area of the

Tarim River, Aksu and Kashgar have much more rainstorm comparing with other places in this area, often in July and August. According to the data available, there is no obvious regularity for time and frequency of rainstorm occurrence. From 1954 to 1980, there occurred on strong rainstorm (2 days or more with daily precipitation over 5 mm and at least one day with precipitation no less than 10 mm) in Aksu. Glacier flash floods often occur in August and September. In addition to high mountain climate as the reason of its occurrences, the advance and retreat of alpine glacier, the volume of glacier melting runoff and rainfall in mountain areas have close relations to them. The floods occurring in June to September always have the greatest peaks in the same year. Their peak discharge has as much as 2 – 4.5 times of the maximum ablation peak discharge in the same year. The similar things would happen mainly in the upper reaches area of the Hotan River, another tributary of the Tarim River.

Comparing GLOF with RFF, the former is much greater than the latter in the volume; both are falling suddenly and rising suddenly in the process; the duration is scores minutes to three or four hours for GLOF, while it is one to three days for RFF. On their hydrography, GLOF has greater beginning flood discharge (>1000 m^3/s) because it often occurs in the severe ablation time. Its Q_m/Q_b (Q_m is maximum peak discharge and Q_b is beginning flood discharge) is always 2 – 3; RFF occurs earlier even in May, and its Q_b is much smaller. Q_m/Q_b can rise up to 3 – 4 or more. In South Xinjiang, GLOF appears in the high elevation area with a height 4000 m above sea level more than, while RFF often occurs in the middle-low mountainous area with an elevation from 1300 to 3800 m.

III. INFLUENCE OF FLASH FLOODS ON MAIN STREAM OF TARIM RIVER

GLOF and RFF occurring in the tributaries of the upper reaches of the Tarim River, particularly GLOF with large discharge bringing about high damage to water conservancy facilities, roads, farmland and peoples life and property in the the Tarim River due to their sudden occurrence, high peak discharge and difficult forecast. For example, the direct pecuniary loss was over 10 million yuan (USD 1.2 million) in the GLOF of 1961 in the Yarkant River. The influence of GLOF and RFF in the tributaries of the upper reaches of the Tarim River on the main streams of the Tarim River are analysed as follows.

(1) The Influence of GLOF in the Yarkant River. Figure 4 is discharge hydrographs at Aral Hydrological Station that is a general hydrological control station for the main stream of the Tarim River, and Kaqung Hydrological Station during the period of flash flood in August 1984. It is stated clearly from the hydrological records that the peak discharge 1800 m^3/s on August 27 in Aral is the greatest stream flow up to now, and the 4740 m^3/s is the third greatest discharge since the founding of Kaqung Station. The figure shows that the maximum peak discharge in the main stream occurred 3 days earlier than that at Kaqung Station. So it can be estimated preliminarily that the GLOF had little influence on the hydrological regime of the

main stream of the Tarim River. The preliminary conclusion can be confirmed by the following details of peak discharge distribution from the upper reaches to the lower reaches of the Yarkant River (Fig. 5).

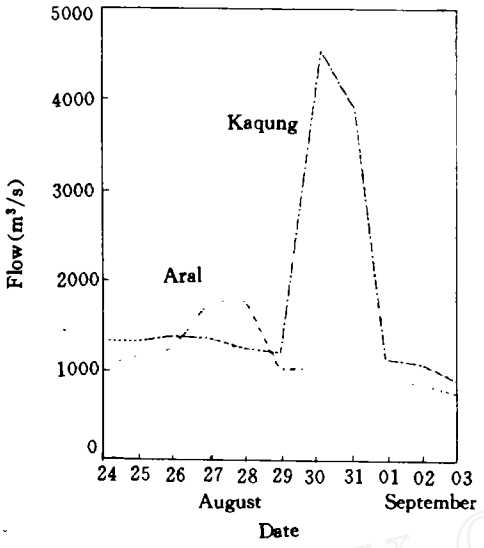

Fig. 4 Daily maximum discharge in Aral and Kaqung

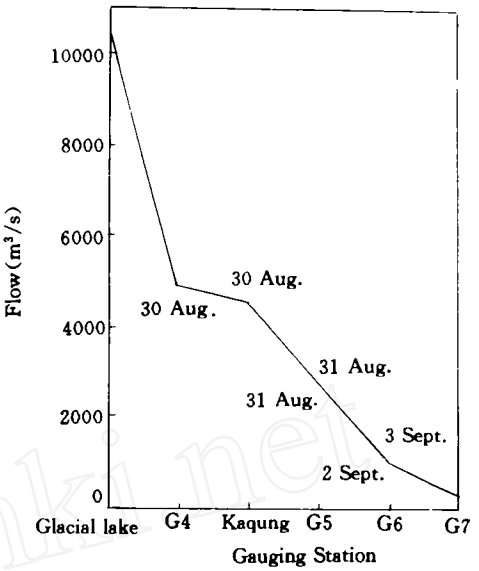

Fig. 5 Maximum peak discharge distribution in Yarkant River

Figure 5 indicates that there is only about 200 m^3/s stream flow in the lower reaches due to the long way of the river course retaining and overflows along the river although the flood has the characteristics of high peak and great volume at the beginning. The reservoir at the end of the river has 78 m^3/s stream flow as its maximum discharge out of the Yarkant River.

In fact, the greatest flood did pass through Aral on August 27. Where did it come from? The cause is the dam collapse of glacier lakes located in the gorge of the upper reaches of the Kunmalik River, which is one of the two main tributaries of the Aksu River, augmented by ablation flood. It is observed that there is a flash flood every year in flood season caused by dam collapse with the characteristics of low water temperature, black water color, very short duration and rapid recession. The average temperature was 9.5 ℃ during 20 th－30 th, while 6.1 ℃ as the lowest water temperature of this month happened on 25th. The flood augmented by ablation flood, formed the greatest peak discharge 1860 m^3/s (August 26) of Gauging Station 2 (Xidaqiao) since its establishment; thereby resulted in the greatest peak discharge in Aral.

(2) Influence of RFF of Aksu River. The annual maximum peak discharge of 1390 m^3/s in Aral in 1971 occurred on August 4 based on observed data. The duration that flood flew from Aksu to Aral was generally one to two days. So the flood on July 7 has not resulted in the greatest discharge in Aral. However, it certainly made the discharge hydrography of Alair have a sub-peak on 8th.

From the analysis above the conclusion would be drown that due to its small scope, not too

great total precipitation and a little runoff, rainstorm occurring in middle-low mountainous area with the precipitation about 50 mm has little influence on the main stream of the Tarim River except the rainstorm center area, although it can bring about flash flood rapidly because of its high intensity.

(3) Influence of GLOF on Environment of the Basin. GLOF resulted from dam collapse, sudden discharge of glacial and subglacial lakes, added snowmelt runoff, always brings about large floods to the Tarim River. The flood hazards and passed-through-reservoirs (losses of their adjust capacity) are popular in the main course in flood season. There is 68% of annual flow of the mains stream concentrating in July to September, however the most of it is depleted in the middle reaches in the way of overflow and seepage loss. On the other hand, only heavy floods can flow down to the lower reaches of the Tarim River. This part of the flood stream has been very important for the existence of populus forest and Green-Corridor that ensures the healthful ecological environment of the Tarim River basin.

IV. SUMMARY

There are two types of flash floods in the tributaries of the upper reaches of the Tarim River. They are glacier lake outburst flood and rainstorm flash flood. GLOF appears in the glacier belts with an elevations over 4000 m a. s. l in the catchments of the Yarkant River and the Aksu River; RFF mainly occurs in the piedmont areas in South Xinjiang.

It is very possible for ablation flood and GLOF to synchronize so GLOF would be augmented by the other. Moreover, rainstorm flood especially in mountainous areas to be difficultly monitored and recorded, to some extent, can raise peaks of ablation floods, even GLOF. It is found that the floods having greater influence on the main streams of the Tarim River are mixed floods——GLOF augmented by ablation flood especially from the Aksu River catchment. The further study must focus on the thorough research of the possibility of the three types of floods to synchronize; the synthetical study on climate of rainstorm, mechanism of runoff; meteorological conditions of occurrence of GLOF and the location, size, growth and dewatering ways of glacier lakes.

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