Karst Water Gushing in Mines

By MIAO ZHONGLING[1]

Dept. of Hydrogeology & Engineering Geology
Guilin College of Geology, Guilin, P.R.C.

ABSTRACT

According to the analysis of 126 mine gushing records and the relevant water supply and hydrogeologic condition, the gush can be classified into eight types: cave type, collapse-column type, subterranean stream type, fault zone type, contact zone type, upper plate type, bottom heaving type and surface water invasion type. The formulae for counting the peak discharge of gushing point are further put forward in this paper.

INTRODUCTION

The sudden issue of groundwater often takes place in mines of mineral deposit bearing Karst water. Water invasion in huge or large degree can result in the inundation of mine and disastrous effects on society and environment. These types of water invasion are related to either Karst aquifer or groundwater flow directly or indirectly. Based on 126 gush records, the problem can be considered as follows.

TYPES OF MINE GUSH IN KARST REGION

According to the hydrogeological structure and the characters of the Karst development on gush points, we can divide mine gushes into eight types:

1. Cave type;
2. Collapse-column type;
3. Subterranean stream type;
4. Fault zone type;
5. Contact zone type;
6. Upper plate type;
7. Bottom heaving type;
8. Surface water invasion type.

In China, huge type of water invasion may reach a discharge of 2035 m^3/min(Collapse-column type, June 2, 1984, Kailuan, Hebei) and 1500 m^3/min(Cave type, August 27,1966, Jiangbei, Sichuan). Such discharges are the greatest of the same kind ever recorded in the world. As a result,we have accumulated rich experience in dealing with and controlling over mine water invasions of huge discharge.

Tables 1 to 3 show the states, properties and distributions of these eight types of mine gushes.

Table 1 The table of gush types Unit: m^3/hr

Type \ Degree	Degree of discharge				Records	Ratio %
	Huge >7200	Large >3600	Moderate >1800	Slight <1800		
1.Cave type	4	1	3	10	18	17.1
2.Collapse-column type	1	0	0	1	2	1.9
3.Subterranean stream type	1	1	0	0	2	1.9
4.Fault zone type	5	8	11	13	37	35.3
5.Contact zone type	0	0	2	4	6	5.7
6.Upper plate type	1	1	0	7	9	8.6
7.Bottom heaving type	3	7	3	16	29	27.6
8.Surface water invasion type	2	0	0	0	2	1.9
Total	17	18	19	51	105	100.0

Table 2 Head pressure distribute of gush point

Head pressure(Atm)	<10	10-20	20-30	>30	Total
Gush records	18	42	11	3	74
Ratio (%)	24.3	56.7	14.9	4.1	100

Table 3 Gush degree table

Factors	Unit	Gush degree			
		I. Huge	II. Large	III. Moderate	IV. Slight
1.Peak discharge	m^3/hr	>7200	>3600	>1800	<1800
2.Head pressure	Atm	$n \cdot 10^1$	$n \cdot 10^1$	$< n \cdot 10^1$	$< n \cdot 10^1$
3.Total discharge	m^3	10^6-10^7	10^6-10^7	10^4-10^6	$<10^4$
4.Drainage radius	km	$n \cdot 10^1$	$10 + n$	$n \cdot 10^0$	$< n \cdot 10^0$
5.Surface collapse		drastic	drastic	drastic	middle-slight
6.Records		18	20	23	65
7.Ratio (%)		14.3	15.9	18.2	51.6

(Total records:126)

THE DISCHARGE REGIME OF GUSH POINT

The peak discharge (Q_{max}) is formed at the initial stage of the gush process and is followed by the decline process of discharge. Decline process is usually regular, which shows the drainage of the aquifer reserves. Based on the observations and analysis of the discharge in the gush point, we formulated the following equations to describe the decline process.

$$Q_t = Q_o e^{-\alpha t} \qquad (1)$$

or

$$Q_t = Q_o \frac{1}{1+\alpha t} \qquad (2)$$

Where Q_t - discharge when time = t

Q_o - peak discharge

α - decline coefficient

The total discharge (ΣQ) in a gush may be obtained by the integrating of Q_t during the gush intervals.The formula is as follows:

$$\Sigma Q = \int_o^t Q_o e^{-\alpha t} dt = \frac{1}{\alpha} Q_o \qquad (3)$$

or

$$\Sigma Q = \int_o^t \frac{Q_o}{1+\alpha t} dt = \frac{Q_o}{\alpha} Ln(1 + \alpha t) \qquad (4)$$

Where ΣQ - Total discharge during gush period from o to t.

DISCUSSION ON PEAK DISCHARGE (Q_{max})

There are 74 complete gush records out of the 126 mentioned in Table 3. These complete gush records have shown the relationship between pressure of hydraulic head and crest discharge (See Fig. 1). The equation used to describe this relationship would be

$$Q_{max} = \alpha (H_t^{\frac{1}{2}} - H_i^{\frac{1}{2}}) \qquad (5)$$

where Q_{max} - peak discharge of gush (m^3/hr)

α - coefficient of gush property, $\alpha \approx 3600 m^3/hr$

H_t - total hydraulic head pressure on gush point (Atm)

H_i - initial of hydraulic head (Atm).

The equation is similar to that of pipeline hydraulics. The initial head varies according to the types of the mine, and three different categories of mines can be found according to their differences in the Karst conditions.

Category A: The caves and subsurface runoff are well developed with little filling but open conduit, giant scale of Karst aquifers and sufficient recharge. If the mine is shallow yet 200-250 metres beneath the groundwater table, the H_i is about 4 Atm for the mines or tunnels in this category.

Category B: Vugular pore space, grit solutional cavity and fractures are well developed,and most of the transmissivity conduits are quite open. Yet the Karst aquifers bury deep even though they are large and thick. If the mines or tunnels are 200 metres to 400 metres beneath the groundwater table, the H_i for these kind of mines is about 7.5 - 8 Atm.

Category C: The conditions of mines in Category C are similar to those in Category B. The only difference of the two lies in that the Kast water flow in mines of Category C transmits through faults or thin layers of limestone, or there may exists certain aquifuge between the mines and the aquifers. Since the total hydraulic head (H_t) is bound to suffer great loss when the Karst water flow breaks through such obstacles, the H_i for these kind of mines is about 12 - 13 Atm.

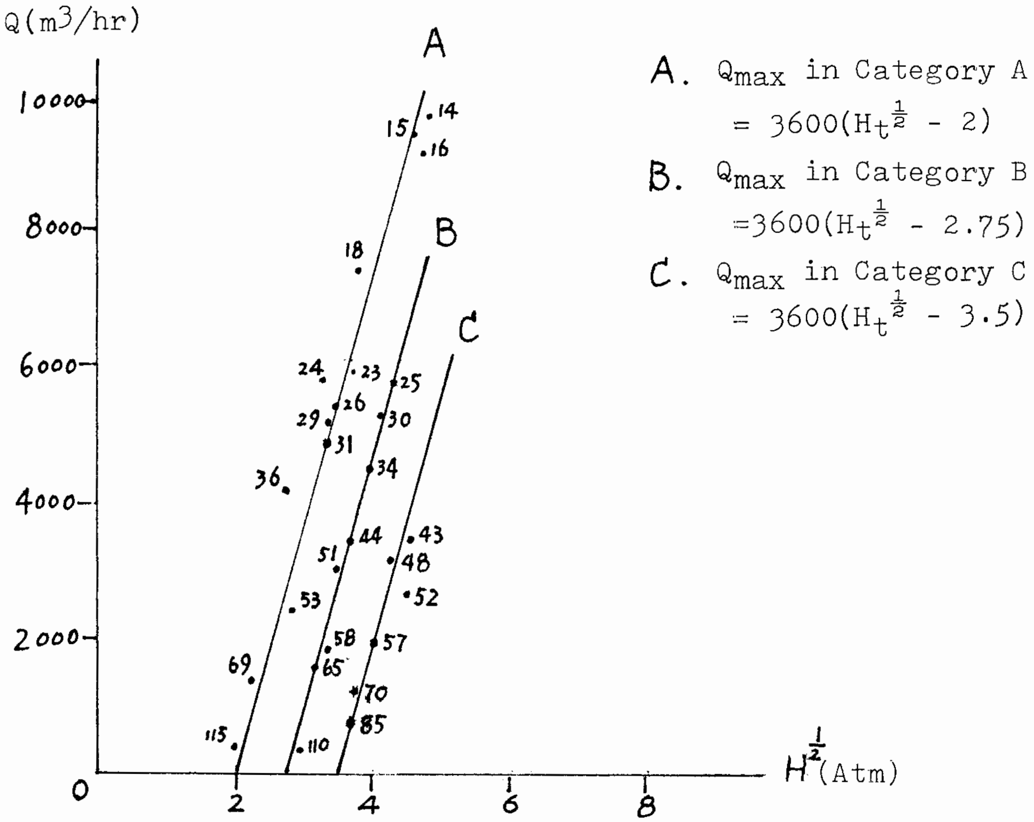

Fig. 1 Gush of mines, $Q = f(H^{\frac{1}{2}})$ curves

CONCLUSION

The gushes resulted from faults, bottom heaving and caves account for about 80 percent of the total number, while the mixed type of faults and bottom heaving is the most important gush in the coal mines and iron mines in the Northern China and the cave type and subterranean stream type are the forms of gush in the bare Karst areas in the Southern China, especially in Sichuan, Hubei, Hunan, Guangdong and Guangxi provinces. The upper plate gush takes place mainly in some mines in Jiangxi and Hunan provinces. The contact zone gush exists chiefly in the Skarn mineral deposits in the middle reaches and lower reaches of Yantzi River. The gush of the surface water body invasion occurs only in the exposed Karst region in the Southern China. The collapse column is a phenomenon of paleoKarst, which was formed over the long geolo -gical epoches. Most developing collapse columns are open and the gush quantity is often extremely great.Although this gush occurs much less often than the other types, it is more dangerous, thus deserving serious attention in the likely areas.

References

1. Zhang Yingjun, Miao Zhongling etc. 1985. Applied Carsology and sepleology (in Chinese) publishing of Guizhou People's, China.
2. Yuan Daoxian, 1987. Environmental and engineering problems of Karst geology in China, Keynote address, Proceedings of the second multidisciplinary conference on Sinkholes and the environmental impacts of Karst, Orlando /Florida/9-10 Feb, 1987.