Application of Shallow Interception of Groundwater in Fankou Lead-Zinc Mine

By PAN BAOYAN,[1] XIE JIFAN,[1] WANG YONGYU[1] and LUO LIANGJING[2]

Changsha Nonferrous Metallurgical Designing Institute, Hunan Province, China

ABSTRACT

Shallow interception of groundwater is a special dewatering form in the specific geological and hydrogeological conditions. It has an economic and technical effect. The roof of the Fankou Lead-zinc deposit is the Hutianqun aquifer made up of the limestone of the upper Carboniferous system. A "water-bearing basin" is surrounded by the aquifuge and the aquitard below ±0 m level at the Shiling Hill section in the Hutianqun aquifer. Based on the natural conditions, an interception gallery is excavated at -40 m level out of "the water-bearing basin", the other gallery excavated at ±0 m level in the poor water-bearing zone of the Jinxing Hill. During 20 years of experience, the better interception effects have been gained.

SHALLOW INTERCEPTION OF GROUNDWATER AND ITS APPLIED CONDITIONS

Shallow interception of groundwater is a special dewatering method used in specific geological and hydrogeological conditions. This method, sometimes with the aid of the additional grouting screen , may drain groundwater from the upper part of the aquifer or from the water-abundant zone to avoid groundwater dropping down as the exploitation proceeds. As a consequence, mine water dewatering can be gained at high elevation. It is economic and advantageous to use this method to decrease pumping elevation, pumping expense and the cost of the drainage works below the interception level as well as the production cost of exploitation. If the interception could keep going to the finish of the exploitation, the economic interest should be incredible.

The shallow interception can not suit to all kinds of geological conditions. It can be used depending upon the natural conditions. Generally, the following conditions are considerable: 1. Sandy gravel aquifer that has an ample recharge with an aquifuge or aquitard at the bottom; 2. A stable confining bed is sandwiched in between two aquifers, of which the overlying is the main aquifer and the underlying is the minor aquifer with no hydraulic connections between the two; 3. No hydraulic connections exist within and out of the orebody area below a certain elevation of the identical aquifer, which is caused by intrusion or structural variation; 4. Within a karst aquifer, the water yield of the upper part is much larger than that of the lower part, therefore, the grouting can be used at the lower part.

HYDROGEOLOGICAL CONDITIONS IN FANKOU LEAD-ZINC MINE

The Fankou Lead-zinc Mine, located in Shaoguan, Guangdong Province, is the biggest lead-zinc mine in China at present. The deposit, mainly with karst water, is on the north border of the catchment basin of 273 km^2, and its hydrogeological conditions are complicated. It occurs in the low Carboniferous (C_1) and the middle and upper Devonian (D_{3m}, D_{3t} and D_{2d}) systems made up of sandshale stone and poor karst-developed limestone on the south and north sides of the Jinxing anticline and the east of the Shiling anticline that are the substructure of the Fankou syncline. These strata are acting as the confining bed or the aquitard. The overlying bed is the middle and upper Carboniferous Hutianqun (C_{2+3} ht) limestone and dolomite, where the karst aquifer is well developed and widely distributed with close hydraulic connectios with the surface water system. The aquifer is about 149m thick on average in the mining area. The upper part is the strong karstified zone (zone A) 75m in thickness. The lower weak-kartified zone (zone B) is about 74m on average. The difference of karst development and water-bearing degree exists between the north and south Jinxing Hill. In the south, the water abundant zone with karst well developed is above the elevation of -20m (surface land is about 110m a.s.l.), the karst ratio 10.44%, the conductivity coefficient K=1.06-19.97m/d; the poor water-bearing zone is below -20m with the karst ratio 0.62%, K=0.38 m/d. In the north, the water-abundant zone is distributed above 20m a.s.l., karst ratio 1.61%, K=0.26-2.54 m/d; the poor water-bearing zone is below 20m a.s.l., the karst ratio 0.16%, K=0.0062 m/d.

North of the mining area is sandshale (C_1 and D_{3m}), west is the limestone (D_{3t}), which forms the confining walls like " ", with open boundaries to the south and east (Fig.1). The ore-bearing zone, effected by the faults 3 and 4 which make the late Devonian and the early Carboniferous strata arising, forms a concealed Qutang anticline between the Jinxing and the Shiling anticlines, and a concealed waterproof wall of the SN strike on the east of the Shiling anticline, which is connected with the confining bed of the southern Jinxing anticline, linked with the impermeable boundaries to the southwest. The Hutianqun aquifer is cut apart below ±0m to the east of the mining area with no hydraulic connections between the outside and the inside. Therefore, the orebody is surrounded by the round confining bed below ±0m as a "water-bearing basin" (Fig.2).

MINE WATER DEWATERING AND INTERCEPTION WORKS

Mine dewatering: Due to the well-developed karst roof above the deposit, the Hutianqun aquifer gains good spaces and permeability conditions to store groundwater. The mining area in a big catchment basin can obtain an ample recharge from precipitation and surface water system, so that groundwater constitutes a threaten to the exploitation because of the large dynamic and static reserves above. In the beginning of the mining, a number of inrushes and floodings took place. The maximum was up to 5000 m^3/h. Pumping mine water has caused subsidence, fracture and land collapse on the surface about 2000 times up to now, which led surface water to the mine. The predewatering should be carried out to pledge the mining safety. Based on the specific hydrogeological conditions of the mining area, the dewatering was determined to adopt by means of the shallow gallery out of the mining-collapsed area to drain groundwater from the Hutianqun aquifer. Within the mining area, the draining adits, tunnels or clusters of openings should be used to the further drainage. Furthermore, flood control works should be built to discharge surface water. The flood diversion channels were excavated on the upper reaches of the Fankou River, and at the foot of the hill near the mine, catchwater drains were dug, and in the collapsed or depression areas, some drain ditches and packing works were built to reduce the leakage from the surface water system.

Interception engineering: Based on the karstified differences at various seams in the mining area, two galleries were excavated on the poor water-bearing zone of the Hutianqun aquifer (Fig.1,2). The northern gallery, 315 meters long, is of service to the orebody on the north of the Jinxing anticline. It was excavated away from the orebody to the east at the ±0m level to catch groundwater from the east. The southern gallery, excavated to the east of the waterproof wall at -40m level, is 881 meters long, to catch groundwater from the east and southeast. Therefore, the orebody in the east of the Shiling anticline can be mined. In order to increase the dewatering effect, 14 draining adits and 40 openings as cluster groupings were excavated at suitable places for about 2039m. Before the galleries reached the Hutianqun aquifer, the gate should be built. When being excavated, some predrills may proceed to observe groundwater at the points where inflow may probably take place. Because the Hutianqun aquifer has a high packing rate of silt, the subsidence is severe after pumping mine water which usually contains 0.15-1% of silt (the saturated silt volume versus groundwater volume). The pumping efficiency was terriblly effected and the rivers will be polluted as well. Therefore, vertical silt sediment systems have been set up in the southern gallery, there silt can settle and then be pumped out by the silt suckers.

EFFECTS OF DEWATERING AND INTERCEPTION

Mine water dewatering began in 1965. As the dewatering went on, the inflow and the drawdown of groundwater increased until 1968 when a some stable depression cone with a big radius was gained in the mining area. In the recent ten years, the total withdrawal has been 30000-50000 m^3/d, the average 37000 m^3/d. In 1987, the centre of the cone dropped down below -20m (the static water level at 101m a.s.l.). The cone was extending about 3000m to the east and the south, and the periphery reached the confining boundaries to the north and west (Fig.1). The water-abundant zone of the Hutainqun aquifer has been dewatered out in the mining area. Since 1968, there have been no critical inflows happened in the mine and the mining conditions have been improved. The interception effects are distiguished.

Northern mining area of the Jinxing Hill: The lowest extraction has reached -160m level. The main inflow still remains at the northern gallery. The average rate of interception is 3745m^3/d. The other inflow points have been exhausted. In August, 1978 when the inclined drift was excavated in the underlying block of the fault 4, inrush suddenly took place through the fractures 450 meters away from the southwest of the gallery. The primary inflow was about 3000 m^3/h. But there was no influence of the discharge of the gallery. It showed that the gallery caught the dynamic reserve from the east and the source of the water inflow at -160m was just from the poor water-bearing zone (the flow amount dropped down to 864m^3/d the next day).

Eastern mining area of the Shiling Hill : In the period of extraction at -200m level, the water inflow from the

Hutianqun aquifer still concentrated in the southern gallery with the interception rate of 18055-29463m^3/d, the average is 24194 m^3/d. Through the equivalent water level in figure 1, it indicates that the groundwater table has dropped down to ±0m below the waterproof wall within the range of the southern gallery. In the latest years, the vertical infiltration has been the only recharge source to "the water-bearing basin" below -40m level with the amount of 500-1000 m^3/d. Some mining work is operating on the poor water-bearing zone, and no large groundwater inflow has been encountered.

Since the two galleries were excavated, the total withdrawal is 20457-35108 m^3/d, the average 27939 m^3/d. Meanwhile, the total amount flowing into the mine from the Hutianqun aquifer is about 28994 m^3/d. The interception rate is about 96%.

The question now is whether the interception effects can keep going to the finish of the exploitation. The southern gallery is to the east of the waterproof wall, and the Shiling exploitation may proceed in the water-bearing basin to the west of the waterproof wall. Provided that the failure to the gallery interception appeared, the necessary conditions needed should be that, when exploitation is operating below -40m level, the depression curve may drop down through the waterproof wall to reach the place below the southern gallery from "the water-bearing basin". The matter mentioned above may exist only when the fractures cut the waterproof wall apart from the east to the west. During 20 years' practice, such situation has never happened and the waterproof wall is reliable. The northern gallery was excavated much earlier, and it has been working over 20 years. The inflow at the inclined drift in the -160m level was a good evidence in 1978. The inflow does not effect the interception rate of the gallery. What should be pointed out is that the gallery was built on the upper part of the poor water-bearing zone. There is no confining bed between the two water-bearing zones or no grouting screen in the poor water-bearing zone, and they are in the uniform groundwater system. Therefore, the possibility of leakage may exist. But the interception rate of the northern gallery is not big. Now that it leaks, there will be little effect to the mine dewatering.

SUMMARY

1. Use of the shallow interception of groundwater is successful in the Fankou Lead-zinc Mine through the experience. When the method is used in the similar mines, the specific geological and hydrogeological conditions should be firstly considered and observed thoroughly. Otherwise, the inflow will cause big trouble of pumping in

the mine, even the mine will be flooded if the failure to interception happenes.

2. Shallow interception of groundwater can eliminate the hazards of the water-abundant zone to the mine. But the location of the gallery must be planned out of the mining-collapsed area to avoid land collapse, and the trend of the gallery must be vertical to the main runoff so as to increase the effect of interception. Therefore, the dewatering engineering can decrease in the mining area to quicken the exploitation.

3. Sandy water can be treated in the interception system in order to avoid causing problems as the mining proceeds. The clear water without pollution can be drained out straight through the gallery for the water supply on the surface.

4. Whether the gallery should be built in the aquifer or in the aquitard depends upon the following conditions: If the aquitard below is relatively stable, the gallery can be built in it. The draining adits, openings and draining holes should be dug along the gallery to lead groundwater to the gallery. If it is unconsolidated or fractured, the gallery can be built in the aquifer or the poor water-bearing zone. As for the karst aquifer, due to the inhomogeneity of the aquifer, it is necessary to excavate draining holes to increase the dewatering effect.

5. The gallery can work long for drainage. Some permanent supports should be used in the fractured zone in order to keep it strong enough for the workers to observe the drainage situation. It is necessary to dig a ditch big enough to ensure the gallery works perfectly.

6. The predrill for observation should be worked out before the gallery is built in the karst aquifer with the inhomogeneity and the gate should be built at the suitable places before the gallery penetrates through the aquifer.

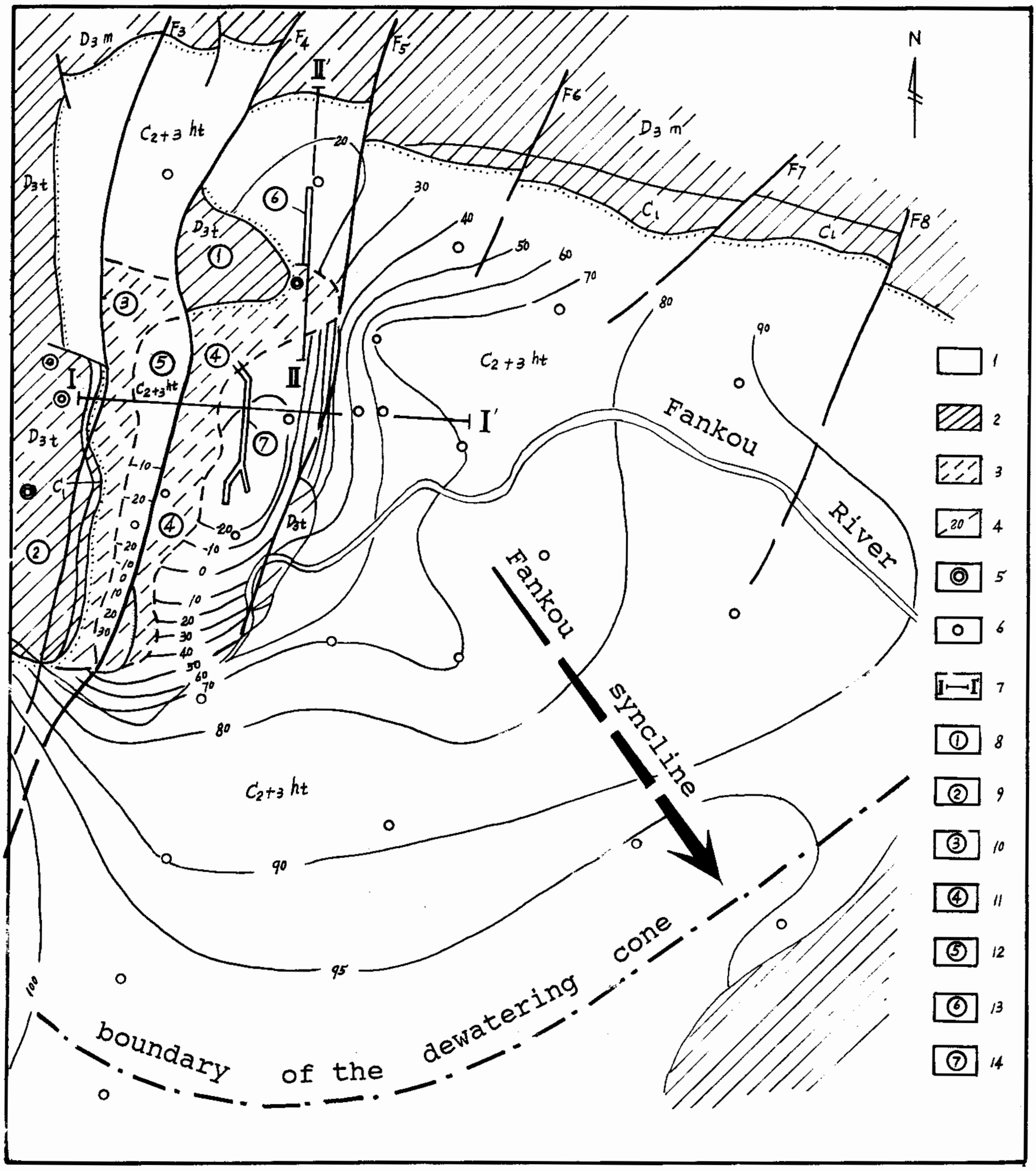

Fig.1 THE PLAN OF THE FANKOU LEAD-ZINC MINE

1. aquifer 2. the confining bed and the aquitard 3. the concealed aquifuge 4. the equivalent water level 5. the shaft 6. the observation well 7. the catalogue No. of the profile 8. the Jinxing anticline 9. the Shiling anticline 10. the Qutang concealed anticline 11. waterproof wall 12. "the water-bearing basin" 13. the northern gallery 14. the southern gallery

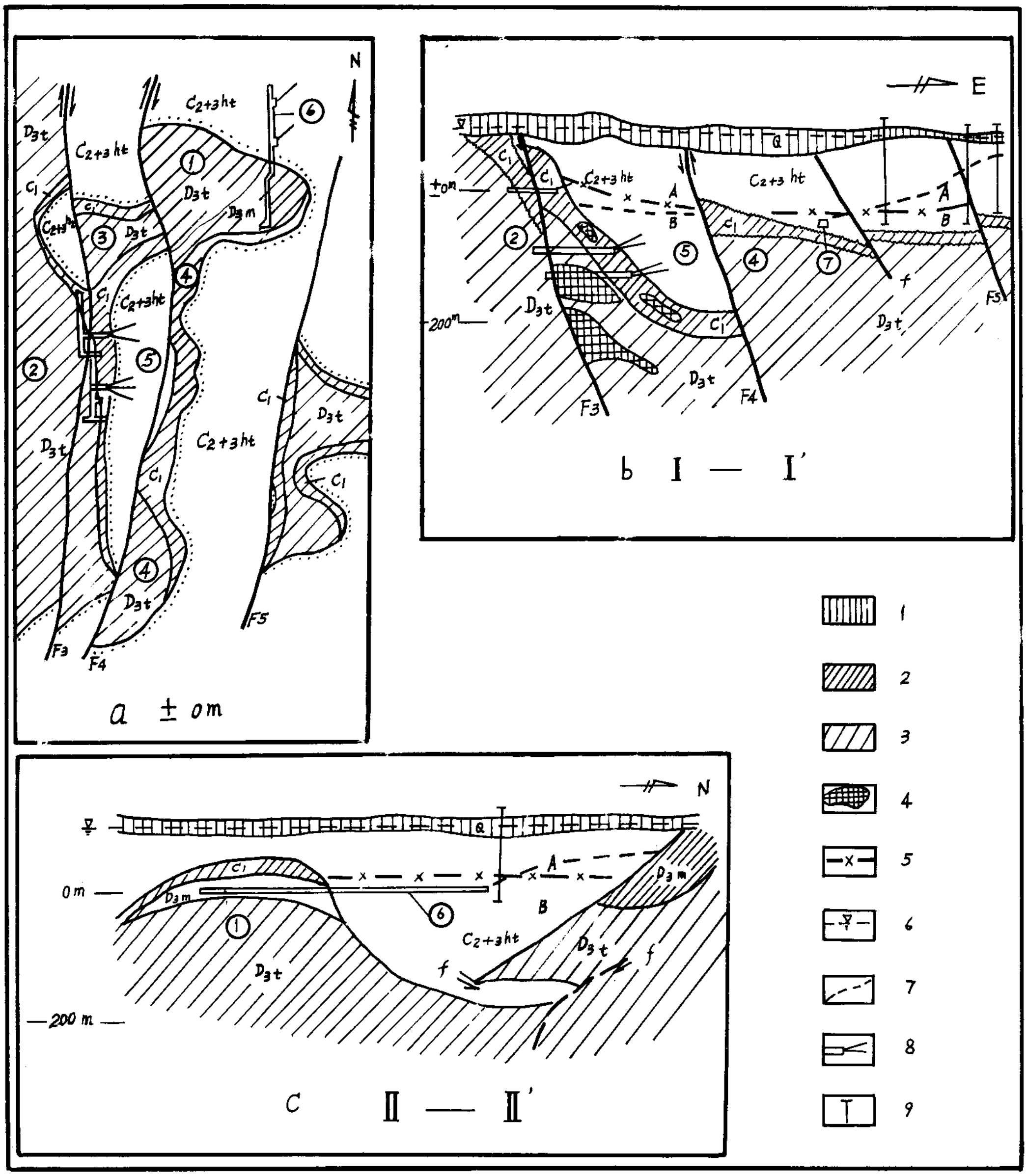

Fig.2 THE ±0 LEVEL PLAN AND THE PROFILE OF THE FANKOU LEAD-ZINC MINE

1. soil layer 2. aquifuge 3. aquitard 4. the orebody 5. the dividing line of the two groundwater zones 6. the static water level 7. the depression cone 8. the cluster of the openings 9. the observation well of the groundwater level