Collapse of the adit “Rothschoenberger Stollen” as a result of the flood on 12 /13 August 2002

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HISTORY

In 1168 the first silver ores were found in the area of Freiberg/Saxony. Very soon the miners realized that the biggest problem was not the depth, but the disposal of the water. Adits were driven from the nearby valley of the river “Mulde” to dewater all parts of the deposit, which were above the adit level, in a depth of about 100 m (from the surface of the shaft “Reiche Zeche” - RZ). For the disposal of the water from deeper parts, a system of artificial canals and ponds was built, to supply water from a 35 km distant river to the Freiberg mining district. This water was supplied to underground water wheels, which in any case were located above the adit level. This energy-water flowed and flows out of these adits. With these water wheels pumps could be driven, which pumped the water from deeper levels up to the adit level. From 1844 – 1877 the adit “Rothschoenberger Stollen” was driven. This adit starts in the valley of the river Triebisch, about 20 km away from Freiberg. A length of 13.9 km of this adit was driven to the north border of the ore district near the village of Halsbruecke. The total depth of the adit in Freiberg is about 230 m, i.e. 130 m below the level of the river Mulde. Within the Freiberg ore district the operating mines were responsible for the construction of the adit resulting in a total length of the adit of more than 50 km. For the construction of the first 13.9 km 8 shafts – so called “light-holes” - were driven from which the construction took place.

In the year 1914, one year after the first closure of all mines, an underground power plant at the shaft “Dreibruederschacht” (DBS) was put in operation. In a depth of 272 m the turbines of the power plant were driven by the water, which was formerly put on the water wheels. This underground power station released the water to the adit “Rothschoenberger Stollen”. After a reopening of some mines in WW II and an operation after WW II, all mines were once again closed in 1969 and due to some problems with CO_2 and the construction of modern powerful surface power plants; the underground power plant was closed in 1972.

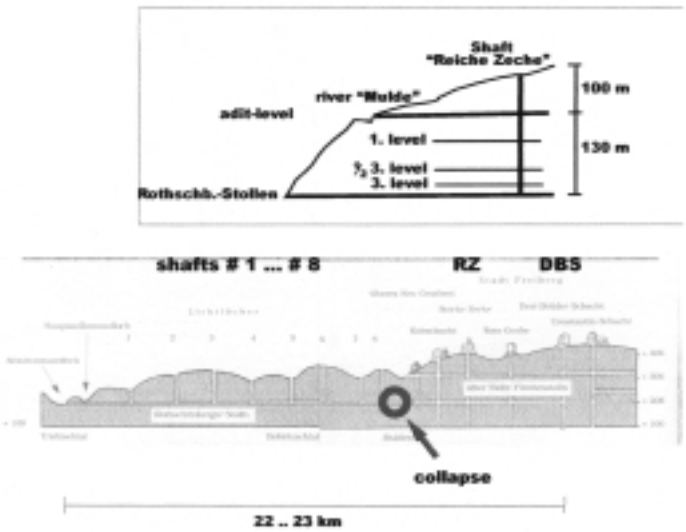

Figure 1. Scheme of the adit "Rothschoenberger Stollen" (lower sketch from information sheet "125 Jahre Rothschoenberger Stollen")

Although there is no producing mine in Freiberg, the adit "Rothschoenberger Stollen" disposes the water from old openings. This adit ensures the dewatering and consequently the existence of the research and teaching mine "Himmelfahrt Fundgrube". The functionality is important for a proposed reopening of the underground power plant. Furthermore the adit guarantees a certain storage and equalization of the water distribution in case of heavy rainfalls. On average between 400 and 1100 l/s water are disposed through this adit.

On the 30/31 July 1897 a disastrous flood caused an inflow of water into adits and mines. As a result, the adit "Rothschoenberger Stollen" collapsed for the first time at the intersection of the heavy spare vein "Halsbruecker Spat" nearby shaft #8 in the village of Halsbruecke. The heavy spare vein has a thickness of several meters and was totally mined in some parts at a length of 1800 – 2000 m. The walls of the stopes were supported by props. At the crossing point with the adit "Rothschoenberger Stollen" the vein has a thickness of about 3.20 m.

The restoration of the adit took some years. At first the collapsed area was supported with heavy iron support. Then a bypass was driven in the region of the ore vein, and the heaviest available support was built in (tamped concrete with old rails, brick-arch in the roof). Then the material in the old path of the adit was removed and the region of the collapse was supported. The miners built in a 14 m long dam, made of gneiss plates (built-in dry – without mortar). In addition to this, two dams were constructed, one at the south end and one at the north end of the formerly collapsed area. The space between the dams and the built-in gneiss plates was filled up with backfill (approximately to the height of the formerly walkway). A total amount of 1080 m^3 of rock was hoisted to the surface.

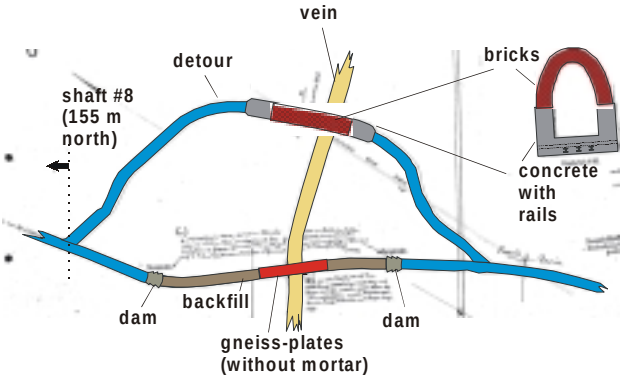

Figure 2: Scheme of the adit with bypass driven in 1897

THE FLOOD ON 12/13 AUGUST 2002

The weather forecast for the 12 August 2002 predicted: rainfall with the chance of heavy rainfall over 50 mm/m^2 in the Upper Saxony Mountains. The day started with heavy rainfall and the water of the rivers began to rise. Already in the afternoon first bridges had to be closed in nearby villages (this is not usual in this region as apposed to flood-prone areas at the river Rhine). In the early evening the first bridge in the village Halsbruecke was closed. Because of the unforeseen and unexpected fast rise of the water level of the rivers many people could not be warned. Within a few hours communication, telephone, fax and power supply failed.

Figure . Recorded flood levels

The firefighters were not able to pump out houses; the only thing they could do was the closure of roads and the rescue of people from drowning. At the night the water exceeded the highest ever recorded level of 1897 by about 50 … 60 cm.

Water from the river Mulde flowed into the adits, the creek “Muenzbach” broke through from the surface to underground openings.

Figure 4: Breakthrough of the creek “Muenzbach” into old openings

On Tuesday, the 13th the damages could be seen: thousands of houses had been damaged or destroyed and about 250 bridges had been destroyed. Helicopters tried to rescue people, one of the most spectacular rescue operation was this of the family in the village Weesenstein, were a complete family went to the roof of its house, waiting for help. Only after 8 (?) hours a helicopter rescued the family from a single wall of the house left in the middle of torrential water.

Miners from the teaching mine went into the shaft via the hoisting cage and suddenly stood in the water, without a possibility to communicate with the hoisting engine. At the mouth of the adit Rothschoenberger Stollen the water came out of the entire cross section of about 6 m^2, but suddenly the volume flow declined to an almost normal level. At the same time the water level in the shaft “Reiche Zeche” was several meters above the adit level, giving an indication that an obstruction or collapse must have occurred.

Figure 5: Outflow from the adit before, during and after the flood

The left picture shows an outflow of about 1.1 m^3/s in spring 2002 (which was one of the highest recorded levels). The picture in the center shows the outflow on 13 August 2002. The measuring instruments stopped measuring at 10 m^3/s, but we assume that 12 – 15 m^3/s left the adit. The re-calculation of the volume flow using the parable equation (parable of the water) gives some 25 m^3/s.

FIRST STEPS OF THE EXPLORATION

The highest water level observed at the shaft “Reiche Zeche” was 23 m above the bottom of the adit “Rothschoenberger Stollen”. Although it was assumed, that the adit collapsed in the region of the ore vein “Halsbruecker Spat”, nobody knew what exactly happened and where it happened. There was always the risk that our boats – formerly fastened in the adit – or wood or other support (bricks, steel) caused an obstruction, which could break through, even if the water level sank. For this reason it was too dangerous to start the exploration from the air side, i.e. the mouth of the adit, immediately. A project group was formed by the Mining Supreme Authority in cooperation with the Institute of Mining Engineering of TU Bergakademie Freiberg, which coordinated all further work. As a first step the water levels at the air side and the water side (in the shaft “Reiche Zeche”) and the volume flow in the adit were measured for some weeks. The approach to a water level to about 3.50 m above the bottom and the comparison with volume flows in the adit over the last 3 years gave the go ahead for the first exploration of the obstruction or collapsed area. Meanwhile private persons had been in the adit. According to these persons, the adit collapsed at the intersection of the mentioned ore vein. Nevertheless it might be possible for private persons to descend to the adit. However, this is not allowed for employees according to strict safety regulations. For this reason first of all the shaft #8 had to be reopened. The entrance via ladders was not possible, some ladders and cross members in the shaft were damaged and weak. After considering different possibilities a temporary hoisting machine with a 400 l bucket was installed.

Figure 6: Hoisting bucket in shaft #8

Figure 7: Hoisting machine at shaft #8

Parallel to the first preparation work many people in villages at the river Triebisch had the fear that the obstruction could break, leading to another flood in the villages beyond the adit. Others had the fear, that the transport and settlement of mud from the subsurface could poison its land. At different meetings the potential danger and precautions against a second flood were discussed. First of all you have to explain to the people, that most limiting values for heavy metals are related to drinking water! Nobody will use adit water as drinking water! Furthermore only a few elements exceed the limiting values, for instance Cd, whereby it must be mentioned, that Cd already exceeded the limiting value for drinking water before the adit water flowed into the river Triebisch. It would make much more sense to compare the values with the limits for waste water input into rivers. None of the toxic elements exceeds these limits!

Table 1: Limits and concentrations of selected elements in the water of the adit „Rothschoenberger Stollen", all values in µg/l

Element	Limits for drinking water (actual decree for drinking water from 05/28/2001)	Limits waste water from non-ferrous industry for input in rivers (decree from 09/28/2001)	Monitoring from 3/1999 – 4/2000, (Institute of Mineralogy, geochemical lab., Prof. Klemm and others) dissolved/total	08/13/2002, (Institute of Mineralogy, geochemical lab., Prof. Klemm and others) dissolved/total
As	10	100	1.5 / 17	nn/1310
Cd	5	200	30/31	51.6/102
Cu	2000	500	16/40	48.8/1780
Fe	200[1]	100 000	17/1217	25/182000
Ni	20	500	43/44	236/324
Pb	10	500	6/40	1.5/2730
Zn	5000[1]	1000 (2000 in chemical industry)	4735/4852	7290/13500

[1] according to: http://home.t-online.de/home/trinkwasser/triwass.htm#TwVO decree for drinking water – old version – only valid until 2003, no value given in new decree

On August 13th the overall concentration of these elements rose again. However this rise was mainly caused due to the rise of suspended particular matter in the water. But parallel to this, the rivers had up to 100 times more water than normal. So the concentration was decreased with the inflow in the river Triebisch, despite of the increased – but limited volume flow from the adit. There was also some concern regarding mud from the adit, which could have settled on the fields. The environmental department made several tests, but as far as I know they did not find any problems.

The first exploration of the damaged part in the adit took place at the end of November 2002. From the shaft #8 to the bypass (of 1897) there are about 155 m. The collapse is supposed to be 50 m inside the bypass.

In the region 25 – 38 m away from the shaft #8 the adit is supported by bricks. At the top some loosened bricks can be seen.

Figure 8/9: Loosened bricks in the roof

After 40 m the first rock mass which settled in the adit can be seen.

Figure 10: Settled rock mass (under water)

Only a few steps away the exploration had to be stopped. The gas-sensors showed CO_2 values of almost 2.6 % and – more important – steeply decreasing O_2 values; the latest recorded value was 13.6 % with a drop from 17 % to less than 14 % within 10-20 m!

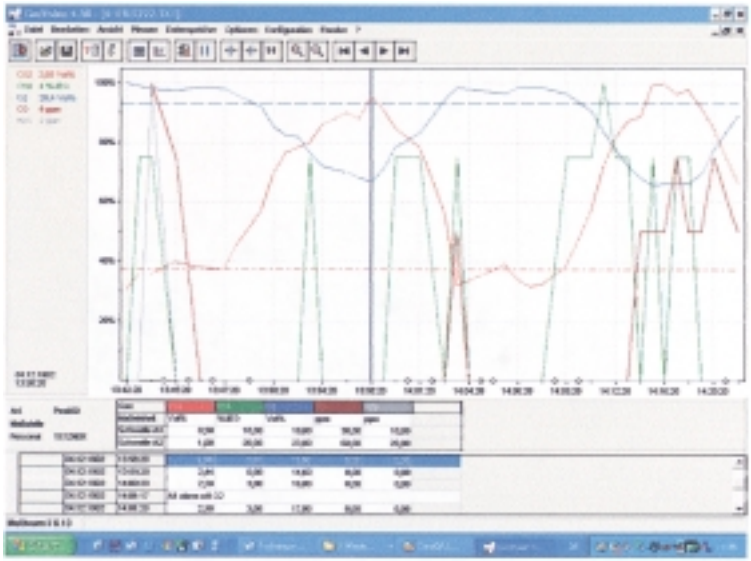

Figure 11: Gas measurement

Figure 12: Rock mass and water filling the entire cross-section in the bypass

The exploration was repeated with compressed air bottles. Nevertheless it was not possible to reach the point, where the roof collapsed, because the settled rock mass became higher and higher and the remaining free space above water decreased.

START OF THE RESTORATION WORK

Knowing now that the adit collapsed in the region of the intersection of the ore vein, different possibilities of the restoration had been discussed. First ideas to pump the water to the surface were not considered. For the pumping of 1 … 1.5 m^3/s more than 1 MW of electrical power would be needed. The construction of a new bypass is also too complicated because:

- the ore vein had a thickness of between 3 and 10 m and was in some parts totally mined
- it is not clear if there are any un-mined parts in the vicinity of the collapse
- the unstable ore vein had to be crossed a third time
- the length of the new bypass would be between 114 – >250 m and
- in any case the region of the collapse had to be secured.

For this and other reasons the project group decided to start with the removal of the settled rock in the straight part of the adit from shaft #8 to the bypass of 1897. The rock in the bypass should be left as an abutment against further sliding of parts of the ore vein. After the flood of 1897 the collapsed area was restored after driving the mentioned bypass. The region of ore vein was entirely supported by rock plates, built in dry, i.e. without mortar, at a length of 14 m (full cross-section). At both sides dams were built. Because the new collapse is in the bypass (only some 25 m apart from the old collapse) it is assumed, that there is a hydraulic connection between the collapsed area in the bypass and the restored part of 1897. It was furthermore assumed, that the supported and restored area of the first collapse was not damaged. There is no possibility for rock to fall down. Consequently, the water level at the water side of the collapse can be lowered, if the first dam is opened. The opening itself against a water pressure of 3.50 m to 5.00 m is not a problem. The dam will only be opened after drilling some holes, whose diameter will be increased later. The pressure in a drill hole of 50 mm diameter would range between 34 300 … 49 033 N/m^2. That is a force less than 70 N … 96 N on the hole, which is the same force which results if somebody holds a bucket with 7 – 10 l water in his hand (330 N … 466 N on a 110 mm diameter hole). There is no problem and no danger for the miners. If a constant water level is reached, the dam can be opened completely.

With modern equipment available today the region of the 1897 collapse can be secured by injections. Than, this 14 m could be mined. With the opening of the second dam the functionality of the adit is restored. Now the collapsed area in the bypass can be secured, for instance with dams and pumped-in concrete.

FIRE AT THE SURFACE BUILDINGS ON 16/03/2003

On Sunday, 16th, at 6.45 o'clock, the firefighters of the village Halsbruecke and surrounded villages were alarmed. Within a few minutes all wooden housings of the hoisting machine, compressor, power station and workshop burnt. At this time 5 miners worked underground. The firefighters could prevent the fire from spreading to the shaft house. After 3.5 hours the miners were rescued by a safety winch. Because of the shaft #8 is exhausting; there was no danger for the underground miners.

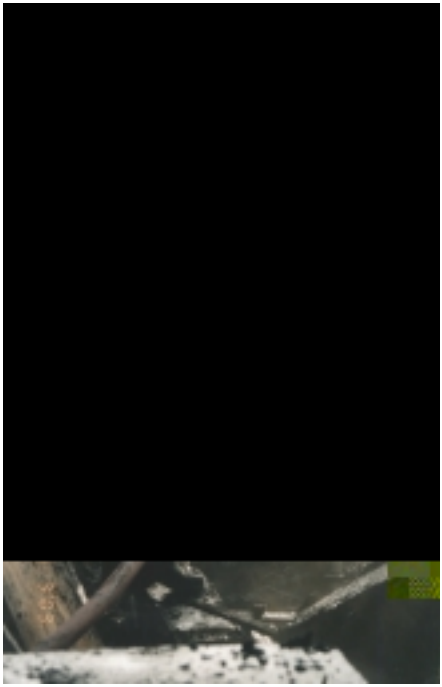

Figure 13: Firefighting on surface

Figure 14: Fuel container

Figure 15: Rescue of miners with safety winch

FURTHER REMOVAL OF THE ROCK

The rock in the adit from the shaft #8 to the dams (the bypass) was removed at the end of April by means of a scraper. It was not possible to use so called “modern, powerful” equipment, like loaders, trucks or belts, which some people proposed. The reasons are obvious:

- the mouth of the adit is more than 14 000 m away from the collapse, no question, that it is not possible to haul material in a narrow adit, filled with 1 m of water (and more) over an irregular bottom, partly filled with 10 – 30 cm of mud,
- there is no artificial ventilation in the adit, except a few meters of ducts built in for the first exploration, leading to a further reduction of the free cross section,
- there is no operating shaft on the way and no sufficient power supply, except the small temporary hoisting machine with the bucket for the transport of men and material at shaft #8.

Scrapers were used in potash mining more than 40 years ago, in ore mining and especially in uranium mining within the Joint Stock Company Wismut more than 10 years ago (in Germany). Rock within a distance of between 5 and 300 m could be removed, the buckets of the scrapers had average volumes of between 0.1 and 3.5 m^3. Scraping was possible in straight openings up to rectangular bends – as done in the former German copper-shale mining. But there was no experience for the scraping in a water-filled adit.

Despite some doubts of some people, the scraper was built in. The winch (11 kW power) was put on a wooden bearing, built in some cm above the water surface at a length of 40 m from the shaft #8 to the beginning of the rock settlement in the adit.

Figure 16: Scraper

Figure 17: Ramp

The pulley was fastened in the adit. The bucket was pulled to an inclined ramp. So the bucket could be pulled out of the water to dispose the rock in a wagon. The wagon was reduced in its height to ensure that it could be filled by the scraper.

Figure 18: Pulley

From the wagon the material is supplied to a short conveyor belt, which fills the material into the hoisting bucket.

Figure 19/20: Conveyor belts loading the bucket

The operation of the scraper was very successful. The fear that material could swap over the ramp was unfounded. Only wooden props and single big rocks had to be removed by hand. The material mainly consists of gneiss, sandy material, material from the ore vein, single bricks and steel members. The age of the props was determined in the laboratory. It could be shown, that this wood is 358 – 360 years old. Obviously this originated from an old stope.

After the removal of the first rock from the adit the restoration of the shaft #8 was enforced. The old cross members and ladders were removed and new once built in.

Figure 21: New ladders and stages

Figure 22: Manhole in the dam

Parallel to this some holes were drilled carefully in the dam at the north end (air side of collapsed area), but surprisingly not much water – or almost no water came out. For this reason it was decided to open the dam completely in June 2003. With the former removal of the rock in the straight part of the adit, the water level was lowered by about 1 m. Now the manhole in the dam could be seen. Unfortunately this cast-iron manhole could not be opened. So the bricks of the dam had to be removed. At first the Mining Authority did not allow any blasting, but revised its decision on a special request. On 26/06/2003 the last bricks were blasted using detonation cord. The next 20 m up to the hand-set backfill consists of waist-high mud. The face of the backfill was stable, only at the sides some water came out.

Figure 23: Stable face (gneiss plates in the vein region)

Figure 24: Walking in the mud (behind blasted dam)

In July the removal of the mud started. For safety reasons it was planned to stabilizes the face (gneiss plates) with shotcrete. Then holes should be drilled into the vein and through the gneiss plates into the former path of the adit. It was hoped, that the water level on the water side could be lowered. Depending on the results the gneiss plates will be rebuilt with or without a protecting injection around the region. With the following opening of the south dam the functionality of the adit will be established. Only then the restoration of the collapsed area can start.

LITERATURE

/1/ Different historical drawings from Mining Archive, compiled by Supreme Mining Authorithy
/2/ Jahrbuch für das Berg- und Hüttenwesen im Königreiche Sachsen auf das Jahr 1898
Fotos: Matthes (Fig. 4), Kugler (Fig 5 middle), Weyer (all others)