

WATER AND SOIL CONSERVATION AT THE LARGE-SCALE COPPER AND GOLD MINE AT PURPLE MOUNTAIN

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Abstract

Mining at Purple Mountain has resulted in a large areas of abandoned dreg and piles of overburden. The constant changes in exposed surfaces have resulted in new difficulties and potential safety hazard issues associated with the prevention and cure of soil erosion. Investigations of the water loss and soil erosion within the mined area have involved assessments of the existing water and soil conservation measures. A range of concrete projects have been proposed along with suggestions regarding additional water and soil conservation measures including the location of ore dumps, displacements of soil or stone field, soak fields and roads. This paper provides a scientific basis for improving water and soil conservation measures.

Additional Keywords: dynamic exploitation, water and soil conservation measures

Introduction

The copper and gold mine at Purple Mountain is located within the boundaries of Shanghang County of Fujian Province. It lies in E longitude 116°24'00"-116°25'22", N latitude 25°10'41"-25°11'44". The mineral structure of this mine is "copper under gold "; it has already verified that there are 153 tons of gold reserves and 1.46 million tons of copper reserves at the mine. Since we started in 1991, we have already implemented the first, the second and the third stage of the technological transformation project as well as the conveyance system. The fourth stage of technological transformation is currently being implemented, and we have already set about our previous work, such as development item feasibility research of copper mine, etc. For over 10 years, we have expanded the scale of exploitation and increased the exploiting amount constantly depending on scientific and technical innovation. This enterprise has already mined more than 47 million tons or ore, producing 3.2 tons of gold, drawn an income of 2.801 million yuan, and got profits 912 million yuan. The fourth stage will enable the production of 6.6 million tons of ore every year. This mine has the largest usable reserves; the largest scale of quarry and selection, the highest output for an individual mine to produce the gold, the lowest comprehensive cost for an ore unit and the best economic benefits of large-scale gold mine in China.

Mining, while providing a "jumping type" development in the economy, also increases the destruction of the ecological environment and causes soil erosion and hidden dangers. Due to the dynamic exploitation of this ore, some situations, such as mineral exploitation amounts and pile dreg field situation etc., change constantly, the water and soil conservation measures designed and already taken originally are difficult to suit gradually with the changes of the situation, thus bringing serious water loss and soil erosion unavoidably, and even causes the mud and rock flow. This ore has already taken place two mud-rock flows so far, One occurred on 25/26 May 1999, rainfall reached up to 120 mm in mining area in 24 hrs, pile dreg field took place mud-rock flow of 50000 m³. Thanks that we have already built up a part of defending system of draining off floodwaters and blocked the mashed dam at that time. We controlled the mud-rock flow to an extent, and didn't cause serious consequence. The other one happened on 25th August 2000, owing to the influence of the 10th violent typhoon in that year, the rainfall reached up to 354.3mm in mining area range in 3 days, which is once-in-a-hundred-year for this area, caused a mud-rock flow of 500,000m³ at the northern displace soil field, made 2# & 3# dams exited overflow dams and erode breached, and reached to Tongkang village, destroying 7 ha of farmland, 11 houses (about 300 m²) by the rush of water, deposited about 1-3 m in the downstream river, causing a great loss. Therefore governments at all levels and relevant department leaders pay high attention to the soil erosion's potential safety and hazard issue, carry on proper combined and supplement to the water and soil conservation measure in this mining area, not only very essential, but very urgent.

Natural Conditions of the Mining Area and Soil Erosion

Natural environment overview of mining area site

This mining area lies in Xinhuaia west rise while leading and north-southern of constructing to the southwest of the tectonic system, its eruptive rock took place in early and later period in Yanshan mountain movement, soil-forming rock is mainly the acid rock formed by granite, account for 70% in mining area. The copper and gold mine in Purple Mountain is characteristic for "copper under the gold", It is oxidation strip above the elevation of 650m; that is the place which composes and stores gold mine. Cause of formation type for Yanshan mountain is later

period secondary volcano hot liquid metal sulphide secondary enrichment gold mineral deposit, industrial type belonging to sulphide – iron cap type, ore body moves towards west-north, obliquity is 44-52°, the longest being 1,150m, the most prolongation is 400 m, the thickest is 171.98 m. While it is shallow-water surface primary strip below the elevation of 650m that is the place which composes and stores copper mine, cause of formation type is secondary volcano low temperature hot liquid mineral deposit, industrial type belonging to sulfuration copper ore type, the distributed range is Line 27-16 , between +700 m and 65 m. The landform around the mine is composed of structural erosion field on the mountain low-to-middle in height, the river valley basin and hill basin among mountain region and it is mainly for granite on low mountain region. Main mining area lies in the top of the highest peak in Purple Mountain, that is Chinese unicorn mountain (altitude is 1138 m), its landform is cut strongly all around, the terrain is high and precipitous, the nearby mountain peak is mostly above 600 m, the relative altitude is 300-500 m. Both sides of mining area are surrounded by Jiuxian river and Ting river; elevation of river surface is 200-230 m.

The soil-forming rock of the mining area is the acid rock relying mainly on granite, the rock body is weathered strongly and covered by cream-red-colored weathering crust for meters. Being worked by climate, living beings, water and some other factors together for a long time, it has formed red earth, yellow earth, purple soil, meadow soil, etc. The vegetations in this mining area are mainly broad-leaf evergreen forest, needle and broad-leaf mixed forest, man-made forest and bushes, etc. Since the ore has been built, we combined grass, shrub, arbor and liana to promote the vegetation recovery of open ground in mining area through artificial plant, mechanical gush and sowing and some other methods. The climate in this mining area belongs to the maritime monsoon climate of subtropical zone, warm and moist, long summer and short winter, the rainfall is plentiful, the average annual temperature is 18.7°C, the extremely highest is 34.7 °C and the extremely lowest is -5.2 °C. Average annual precipitation is 1600-2100 mm; the rainfall is usually concentrated on from April to September, accounting for 75% of the whole year. Typhoon and rainstorm often take place in summer and autumn; it is easy to cause flood water rushing down the mountain, and even mud-rock flow and landslide

Soil and water loss within the mining area

According to the inspection and survey on the spot by Shanghang county's water and soil office, this ore has occupied perturbation land 4.37 km², 1.25 km² of soil and water loss area now, the soil and water loss rate is 28.6%, there into, intensity loss is 1.09 km², accounting for 87 %, and slightly loss is 0.16 km², accounts for 13 %. It had caused the earth's 125 ha uncover surface over the years, and soil erosion endangered 26 ha of farmland, damaged 4 roads, destroyed 11 houses by rush of water, silted the river reservoir 200000m³ because of mining. Due to serious soil erosion and potential safety hazard problems, the inhabitants of Tongkang County who live in the northwestern mining area have to move altogether, now 230 houses; 1040 people have already finished the relocation tasks.

The mineral deposit structure of Purple Mountain is "copper under gold", we are mining on open air on the top of the hill whose altitude is 1138 m, the characteristics of the destruction to water and soil is as follows: first, large amounts of exploitation and abandon dregs, since built the ore, there are about 7.5 million tons mineral exploited on average and up to 8.2 million m³ dregs abandoned every year so far. Second, large perturbation and destroyed area, there are about 4.37 km² perturbation land on mining area now, after the fourth stage of technological transformation project and two projects of copper mine in place, newly-increased perturbation land is 2.95 km², perturbation and destroy of the land reaches up to 7.32 km², and distributed discontinuously, concentrating most on the mining field, arrange soil (or stone) filed, pile field etc. Third, its ground are complicated, high mountain and steep slope, the terrain is precipitous, strip layers of topsoil to the north end set slopes free throw aside naturally in mining area in a large amount, abandon soil and abandon dreg put slope up to 350-450m, it is much difficult to bring it under control. Fourth, the ore is dynamic exploitation, and coexists "exploit, destroy and control" with "control before cover with destroying", as a result, it impacts on the water and soil conservation measure to some extent.

The trend of soil erosion near middle period of mining area reflects mainly in two following great projects:

- (1) The project of solid waste comprehensive utilization and environmental renovation. On the basis of the data of water and soil conservation scheme report, newly-increased perturbation and destroy area reaches 1.61 km², waste residue (soil or stone) is up to 63 million m³ during construction and production of this project, among them, road construction and lever off field is 262000 m³, pile and soak dregs are 53.97 million m³, disused tailing is 8.8 million m³, drain off floodwaters and tunnel dreg is 64,000 m³. The construction and production of this project is in the case of not taking administration measure, thus it may

cause soil and water loss to be 5371 t yr⁻¹ and 67131 t yr⁻¹ respectively in the capital construction time and production time.

(2) The project of the copper mine exploitation. On the basis of the data of water and soil conservation scheme report, this project construction is produced during this time, newly-increased perturbation and destroyed land is 3.11 km², the amount of waste is 79.28 million m³ during construction and production of this project, among them, there are 1.06 million m³ abandoned soil and stone in capital construction time and 2.7 million m³ in production time and 75.5 million m³ production pile and soak dregs. The construction and production of this project is in the case of not taking administration measure, it may cause soil and water loss to be 33925 t yr⁻¹ and 180862 t yr⁻¹ respectively in the capital construction time and production time.

The Existing Water and Soil Conservation Measures

Water and soil conservation measures

By 2003, the ore owner had already invested 50.95 million yuan, which used to control water loss and soil erosion in mining area. There are 46.49 million yuan invested in the project measure and 4,461,000 yuan in the plant measure. The major project measures as follows: 1) Build up some new stop dreg (or water) dams, such as Xinwuxia, Sanqingting, Duzikeng, Ermiaogou, Jinzihu, etc., it has already invested up to 20,720,000 yuan; 2) Completed the north #2 stop dreg dam, stop mud dam and slope renovated, which invested up to 16,560,000 yuan; 3) Build many drain off floodwaters and tunnel holes and canals in the north Dayanli, Chishui, Yutiankeng, Dachebei, etc., its total length is 2900 m and it invests 4.2 million yuan in all; 4) In tailing dam, soak dreg field, smelt building site, etc. we have built up intercepting ditch, drain off floodwaters ditch (or hole, canal), preventing seepage dam, etc. facilities. The invest is up to 3,620,000 yuan; 5) Invest 1,351,000 yuan to other water protect projects

The main plant measures are: (a) The virescence project of tailing dam, which have been invested 199000 yuan; (b) The slope virescence project of the first, second and third stage of technological transformation, which have been invested 1.8 million yuan; (c) The slope virescence project of the fourth stage of technological transformation, which have been invested 2.2 million Yuan; (d) The slope virescence project of the road in the mining area, which have been invested 152000 yuan. By 2003, the mine planted over one million trees and planted turf on an area of 319400 m².

Analysis of the water and soil conservation measures

Since the owner of this mine built up the mine, he declared and carried out the first three stages of technological transformation project of water and soil conservation scheme successively, and the fourth is being implemented now. The water and soil conservation facilities which have been built up in this mine, except that some are buried by the slags exploited newly, the majority can normally run, and there are three dams in north – Shiliaoli, Xinwuxia, Sanqingting, which have already passed the security qualification of relevant departments and organizations. These facilities have played an important role in preventing and curing water loss and soil erosion in mining area, made a certain effect, and have lightened and controlled the dangers in water loss and soil erosion to a certain extent. For example, a mud-rock flow of 50,000m³ happened on May 26, 1999 in the north pile soil field, thanks to that we have already built up a part rows of flood canals and stop mud dams at that moment, cutting to guide the most mountain torrents to leave the pile soil field and stop mud function of blocking dam, preventing the heavy mud-rock flow effectively, make a better result in prevention and cure project. In addition, slope erosion and gully erosion are obviously mitigated, plant measure to prevent and cure soil and water erosion also make effect in the places where vegetation recovered better at some dreg fields., However, we can't overestimate the function of soil and water conservation measure, and can't be optimistic with the situation faced in water and soil conservation in mining area, the following subject matter and hidden dangers still exist. First, this mine is dynamic exploitation, and its scale is larger and larger, the abandoned dregs situation are also dynamic, and its quantity is more and more serious, the owners proposed the schemes between the different water and soil conservation of development item in different period, lacking of connection and join, so that they couldn't consider water and soil conservation planning and overall arrangement according to "copper under gold" in Purple Mountain, therefore influenced the validity and security of soil and water conservation measure; second, water and soil conservation measure lags behind seriously, only when problems come out, can attentions be paid, existing the phenomenon that "treat the head when the head aches, cure the foot when the foot aches," piecemeal phenomenon; third, some water and soil conservation facilities exist "bury after building", which not only leads to waste but also influences the function of water and soil conservation facilities; fourth, there are still great potential safety hazard existed, especially the pile soil field in the north, in which has already formed a large deposit that slope long is about 450 m, the width is about 150 and

the thickness is 30-100 now, and its slope is precipitous, about 30°- 50°, according to "Longyan area hydrogeological manual", the phenomena that the rainfall reaches up to 170mm in 24 hours in this mining area reappears every 10 years; that is to say, the mud-rock flow, such as which happened on May 26, 1999 (rainfall is 120mm in 24 hour), reappears sooner than 10 years; fifth, vegetation recovery and ecological view construct are still very arduous; according to the investigation, it is only 26% that the vegetation is covered within the mining area at present

Supplementary Concrete and Other Water and Soil Conservation Measures

Goal and principles

As far as the ore of long-term dynamic exploitation is concerned, it is abandoned dreg quantity's dynamic change characteristic that determines the differences between the goal of soil and water loss prevention and cure and the goal of development and construction prevention and cure for once in short-term, according to Purple Mountain mining area's actual conditions, the main goals of combining prevention and cure are followings. (1) The coverage rate of soil and water conservation project measure should be more than 90%; that is to say, except that little to pile up temporarily, most arranging and abandoned dregs should be in the range of the project measure. (2) Block dreg rate should be more than 98%, through building step dreg dam, block dregs effectively. (3) Vegetation coverage rate should be up to 40%, expect dynamic abandon dreg field and pile soak place, other soil layer or dregs locations should be virescented and beautified accordingly, promoting the ecological view of mining area to recover. (4) The controlling rate of soil and water loss should be up to 85%. The main goal is to prevent the calamitous mud-rock flows from taking place essentially and lighten the dangerous of soil and water erosion as much as possible.

First, safe and reliable principle. Through supplementing to combine, we should bring the soil and water conservation facilities which have existed and to be supplemented in future into play the whole function, reduce the rate of heavy harmful mud-rock flow and soil and water erosion as much as possible (obviously the light harmless mud-rock flow and a certain amount of soil and water erosion is difficult to completely avoid), in order to ensure the ecological safe of the mine production and surrounding environment. Second, dynamic and effective principle. The characteristic of water loss and soil erosion of this mining area is exploitation, arrange and prevention and cure at the same time, we must hold the "dynamic" characteristic to combine and supplement soil and water conservation facilities, considering every possible aspects, in order not to get half result with twice effort. Third, the feasible technology principle. The soil and water conservation prevention and cure in mining area involved in project measure and plant measure, the technology is complex, while considering the rationality of whole overall arrangement, we must also consider its feasibility from the technological aspect, so that we are convenient for implementing and guaranteeing the security. Fourth, the rational economy principle. Generally speaking, the degree of security and reliability of soil and water conservation facilities and its invested amount are in direct ratio, namely, the more fund inputs, the higher its security and reliability are, as the mine exploitation enterprises, obviously the cost must be accounted, the principle is under the condition that it is safe and valid, save the fund as much as possible, avoid causing the unnecessary waste.

Concrete measures and the overall arrangement scheme

The area of this mining is up to nearly 1km² at present, one cause of the mud-rock flow happened on August 25, 2000 in the north is a great deal of flood to drain off water in improper direction, we should draw the lesson to forbid the flood from overflowing to the north absolutely. Main measures: one is to remain "high north and low south" situation in opencast mining places certainly, each platform exploited should keep above 30-50cm discrepancy between the south and the north; The other is to establish several drain off floodwaters tunnels in southern slope, their number and size should design according to the standard of once in 20 years, so as to ensure that the flood of about 1km² collective rain area in the mining should be guided into the southern direction

According to the current situation in 1 to 10000 topography offered by this ore, we calculate that the north displacement of soil field had formed a row of deposit, which length is about 1000 m, the width is about 910 m and the thickness is about 20 m, the total amount reaches up to 18.2 million m³, occupation space reaches 0.65 km², the elevation of naturally abandoned soil and stone is 400-500 m with a slope of 30-50°. This dangerous position is the most probably one to take place mud-rock flow, but the existing measure is quite weak, there are only floodwaters canal (or hole) in north and #2 dregs dam and #3 mud dam, etc. The difficulty to control also lies in constantly increasing dregs.

During the period when the fourth stage of technological transformation project is implemented, the major supplement of soil and water conservation measures are as follows:

(1) The former 12 years of the fourth stage of technological transformation: 7-8 ditches should be set up on both sides of the north pile every 50m which specification is 1x0.5x0.5m and about 100m long, one side closely attaches to the pile, the other has an 45° angle downwards, which links with newly set ditch in both vertical sides. By this way the inclined ditch forms “a slant ladder” structure. The ditch may link with current drain off floodwaters and tunnel or may discharge from the lower safe place. This measure can prevent water from both sides of the pile from washing soil in the north in order to lighten or avoid the probability of mud-rock flow.

(2) The latter 4 years of the fourth stage of technological transformation: From the 13 to 16 years of the fourth stage of technological transformation, we should combine with the opportunity that enterprise recycles dregs which gold content is under 0.2g/t to deal with deposit in arranged soil field, that is to say to make use of the platform formed by the north #2 dregs dam then transport the soil and stone to the platform to pile and soak in every layer, every 10m is a layer, which remains about 20m bridle path, and then clear up and virescent the slope ground. Abandoned soil and stone which can't be utilized should also be formed into small platform every 15m with 2m width, and big platform every 30m with 4m width. Wall ought to be designed according to 1:2.5 outside platform, drain off floodwaters ditch ought to be set up inboard, press every layer and virescent it.

Seeing from existing drainage system, the ore had already been invested 4.24 million yuan, water drainage tunnels and canals which are 2900 m long have been built, the drainage system almost surrounds the soil piles and field entirely, which plays an important role in intercepting the peripheral flood. However, there is still 5.0-5.5 km² water gathering in the inside surrounded by the drainage system, which threatens the production of pile and the security of downstream Ting River. Therefore, supplement measures must be added as follows: first, set up a new dam at suitable location (Jingzili) between the #2 dregs dam and mug dam whose capacity is 2 million m³. This dam can both intercept the flood and stop the upper wastewater. At the same time, a spillway should be set up on the right bank of dam to link with the existing tunnel. Second, an inner drainage in the existing drainage should be set up in the north; it moves roughly according to the outer ring, the space is about 300-400 m, the total length is about 6-7km, the designing specification should be smaller than a classification standard of "outer ring".

This ore was run by a private enterprise originally, and it merges into this enterprise now. According to the investigation, it has formed a huge deposit about 810m(long)×245m(wide)×240m(thick), total amount reaching 3.97million m³ now, hillside is precipitous (original slope is 40-50°, 30-45° after piling) and very easy to slip or come into mud-rock flow, which seriously threaten lower river's residents. Due to above-mentioned reasons, water conservation of this place was not included into the existing ore's water conservation. The following supplementing measures should be added: small platform should be formed every 15m-20m with 2.5m width, while big ground every 30m-40m with 5m width. Wall ought to be designed according to 1:2.5 outside slope, drain off floodwaters ditch ought to be set up inboard, press every layer and virescent it.

Along with the ore's mining scale enlarging consistently, from which derives some new items matching with perturbation and destroy physiognomy, which haven't been included into water conservation. In addition, because of the dynamic exploitation characteristic of the mine, the ore's new abandoned dregs have buried some already existing vegetations in some locations, as a result of producing new bare ground; And the enterprise proposed the imagination of building "industrious eco-tour" in the mining area recently, and so on, all of these factors determines that plant measures in this district must be supplemented and combined. Main measures: 1) level off abandoned dreg field first, spray and wash the surface to reduce harmful substance, and then cover it with soil, select some grass and tree which could bear drought to virescent the land; 2) adopt "covering quickly by mixed spray" technology to deal with and supervise the bare place because of factory building and resident districts, whose sight is demanded high; select garden plants such as arbor and shrub for the resorts which have been listed as industrial eco-tour programming already; choose good adaptability and cheap local plant for the place requiring general sight in order to lower cost; take measures to virescent according to local conditions for new road, pumping equipment and bare slope and dregs, in order to improve the vegetation coverage rate and resume ecological sight in mining area as much as possible.

Conclusions

It is a difficult problem to control the soil and water erosion in the dynamic exploitation of large-scale mine, it involves in a wide range of knowledge and changes constantly, how to deal well with the relation about economic benefits, security and ecological protection and look for a best coalescent point is a great subject which is worth exploring for a long time. The Company of mining industry of Purple Mountain, under the existing conditions, in

order to prevent and cure soil and water erosion and even mud-rock flow calamity, has already put into a large number of people, wealth and material resources and set up a batch of project measures of water and soil conservation, but that still can't completely exclude the possibility of occurring the mud-rock flow calamity, we propose to go deep into experimental study to this question. It is also a great subject to build the large-scale mine into "ecological tourist zone of industry" through the vegetation recovery and ecology rebuilding and should be explored for a long time. Seeing that the vegetation has been destroyed seriously and the situation of abandon dreg, soil barren and lack of moisture in this mining area, we propose strengthening the district experimental study about vegetation recovery in the mining area, selecting the suitable arbor, shrub, grass and liana plants, in order to improve the success rate of vegetation recovery

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