Environmental problems in the mining of metal minerals

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Abstract. During the mining of mineral resources, it will inevitably cause problems in the mine environment. According to the different ways of expressing environmental problems in mines, they can be divided into three categories: geological disasters, environmental damage and environmental pollution. Among the three mine environmental problems, environmental pollution has characteristics such as concealment, post-hazard hysteresis, watershed diffusion and accumulation, which cause serious damage to the mine environment. This paper focuses on the current status of environmental pollution problems in metal mining.

1. Classification of mine environmental problems

In the process of mining, it is impossible to avoid the environmental problems of the mine, but the form of its performance varies with the minerals. The environmental problems brought about by mining activities can be classified into three categories: geological disasters, environmental damage and environmental pollution (Table 1) [1]. Geological disasters are changes in the topography and geomorphology integrity during the mining process, and are caused by the mechanical balance of the rock and soil in the mine activities. Environmental damage refers to the destruction of scenic spots, natural landscapes and topography when the soil is mined, quarryed, and piled up in the mining process. Environmental pollution refers to the destruction of vegetation and cultivated land by mining activities such as mining, selection and smelting, changing the air, water and soil conditions on which the organisms depend, causing ecosystem damage and ecological disorders. Geological environmental problems and landscape environmental problems have limited scope, are intuitive, and are easy to attract attention, so that problems can be found and the root causes of problems can be found, and problems can be solved by engineering means, and prevention, treatment and repair are relatively easy. In contrast to ecological and environmental problems, pollution has the characteristics of concealment, post-harvestness, watershed diffusion and accumulation. In particular, mine pollution, mostly complex pollution, accumulates in sediments of the basin and becomes persistent pollutants [2].
Table 1. Classification of mine environmental problems.

| Category          | Manifestations                                                                 |
|-------------------|--------------------------------------------------------------------------------|
| Geological disaster | Collapse, ground rips, landslides, mudslides, soil erosion, damage to water balance, etc. |
| Environmental damage | Waste of resources, land occupied by solid waste, destruction of land resources, waste station vegetation. The open-air vegetation is stripped, the spoil is removed, and the geological remains are damaged. |
| Environmental pollution | Three wastes pollute water bodies, soils, vegetation; air pollution and the resulting ecological and environmental diseases. |

Generally, in the process of mining, the three environmental problems of geological disasters, environmental damage and environmental pollution exist simultaneously. The main manifestations of mine environmental problems arising from the mining of different regions and different minerals are different. According to the topography, hydrological vegetation, and geotechnical properties, China's mining problems can be divided into Gobi desert area, plain basin area, Loess Plateau area, middle and low hilly area, middle and high mountain area, permafrost area, etc. Discuss it [3]. Among them, in the hilly area of the mountainous area, the environmental problems in the development process of the deposit are mainly manifested by landslides and mudslides, such as Sichuan, Yunnan, Hubei, and Guangxi. In the areas of plain vegetation and bio-community, vegetation and ecosystem damage are the main factors. In the Loess Plateau, mine wastewater pollution is the mainstay. In permafrost and Gobi Desert, due to its fragile ecological environment and poor natural environment, environmental problems are dominated by ecological damage.

2. Metal mineral environmental issues

During the mining of metal deposits, the alpine region is dominated by geological disasters such as landslides and mudslides. The plains are subsided by the ground and occupied by land resources. During the mining process of metal deposits, the pollution generated is mainly caused by acid mine drainage and heavy metal pollution. The main sources are ore heap leaching and tailings reservoirs.

2.1. Hazards of metal mine pollution

The exposed bedrock on the earth can form secondary minerals during the weathering process. The formation and dissolution of secondary minerals on the surface of the bedrock is an important way for the release and diffusion of heavy metals and acidic substances into the surrounding environment. For example, the exposed rock in the Great Smoky Mountains National Park area contains metal sulfide minerals, and the heavy metals and acid wastewater generated by weathering have direct and indirect effects on the surrounding ecosystem [4]. However, from the source of heavy metal pollution, most of it originates from the mine; from the cause, it is mainly caused by human factors, and the natural release is relatively small; among the human factors, the exploration and exploitation of minerals account for the main part [5]. Metal mine pollution hazards can be divided into two categories, surface acidified water and heavy metals release and spread.

2.1.1. Surface water acidification. Acid mine drainage (AMD) is mainly diffused through water systems, causing direct damage to the environment, such as the collapse of regional ecosystems and desertification of soil environment. For example, in the mining process of Datian sulfur polymetallic ore in western Yunnan, a large amount of acid water enters nearby rivers and farmland. The aquatic plants are abundance and death, the animals are slow to develop, deformed, and even extinct, the biodiversity is reduced, the ecosystem is seriously damaged, and the farmland is polluted by mine acid wastewater to reach tens of acres, of which 30 acres of farmland rice yields are reduced by more than 200kg. 3 acres of farmland cannot grow crops due to serious pollution [6]; iron-polymetallic ore deposits in the northern part of Hubei Province produce a large number of acidic water bodies, which are discharged into the cross-rock water without treatment, causing the collapse of the river ecosystem and
serious pollution. In the river section, the color of the water body is red, the mud is black, and a large number of fish and shrimps are extinct [7].

Hammarstrom et al. (2003) have shown that pH has an important influence on the absorption equilibrium of heavy metals in the absorption matrix. Under acidic conditions (pH<4), the adsorption of copper and zinc on vermiculite is close to zero, copper and zinc are mainly in the form of ions, and when close to neutral water, the adsorption capacity of vermiculite reaches 100% [4]. This indicates that the degree of diffusion of heavy metal pollution in the mine is enhanced under acidic conditions. That is to say, the dissolved heavy metal content caused by the acid waste water in the mine is abnormally high, which will endanger the wider water ecosystem.

Acidic wastewater and its interaction with heavy metal pollution are common problems faced by many mines around the world. According to a survey by Johnson & Hallberg (2005), approximately 19, 300 km of rivers and 7, 200 km² of lake water systems worldwide are subject to AMD pollution [8]. The severity of the hazard has also been reported. For example, in the mining lake formed by the Getchell Gold Mine in the United States from 1968 to 1986, the water body pH is lower than the surrounding area, and the SO₄²⁻ content is as high as 1640 mg/L. The mine pollutants are seriously exceeded. The concentration of as is up to 0.59 mg/L [9]. Another example is the Wheal Jane mine in the United Kingdom. Because the acid water is discharged into the Carnon River in the mining area, the pH of the river water drops to about 3, which leads to the contents of As, Cd, Cu, Fe, Ni and Zn in the water bodies reaching 6000 and 600 respectively. Amazing high limits of 7000, 600,000, 1200, and 440,000 μg/L [10].

There are also a large number of AMD pollution reports in China. For example, the mining of polymetallic sulphide deposits in the Dabaoshan area of Guangdong Province has a history of 40 years. During the mining process, a large amount of mine acid waste water is formed and enters the environment. In the sediments of the Hengshi River tributary downstream of the mine, the maximum contents of four heavy metals of Cd, Cu, Zn and Pb were 14, 541, 4577, 341 and 2926 mg/L, respectively. It seriously exceeds the national secondary standard for soil quality [11]. The water body pH is 4.25, and the average contents of heavy metals Pb, Zn, Cd, Cu, Ni and Cr are 0.218, 9.538, 0.019, 0.823, 0.063, 0.009 mg/L, respectively. The contents of Pb, Zn and Cd are seriously exceeding the irrigation water quality standards [7]. Dexing Copper Mine is the largest porphyry copper mine in China, and it is also the earliest copper mine enterprise in China to reach the “green mine” standard. Its mining led to a significant drop in the pH of the downstream Le‘an River basin, which was 5.8-7.8, and various heavy metal contents were abnormal. For example, the dissolved Cu content of the Dawu River was 5960 μg/L, and the dissolved Pb and Zn contents of the Qinshui River were as high as 22.4 μg/L and 218.4 μg/L, the dissolved Cu content in Le‘anjiang River water is 2.28-9.942 μg/L, and the Cu content in sediment is 10.43-1651.8 mg/kg [12]. With the “World Capital” Hunan tin mine antimony ore has a 200-year mining history, the area is affected by acid mine drainage, surface water and groundwater pollution. The average concentration of Sb in surface water reached 10.28 mg/L [13].

2.1.2. Hazards of heavy metals. Heavy metal pollution can cause harm to the growth, development, reproduction, and behaviour of living things.

Heavy metal refers to metal and metalloid elements with high density (>4g/cm³ or more than 5 times water density), and there are about 45 elements, including: Pb, Cd, Zn, and Hg, As, Ag, Cr, Cu, Fe, and platinum-based elements. Most heavy metals are toxic to organisms at lower concentrations. Heavy metal elements are a major component of the earth's crust and a major component of rock. In rock, heavy metals are mainly present in the form of sulfides, and a small part is in the form of oxides. In environmental science, As is a non-metallic element with similar properties to heavy metals, and a very small amount will be toxic to the environment, so it is customary to classify it as a heavy metal. Different organic pollution, heavy metals will not degrade under any environment; so when they enter the environment, they become environmental pollutants [14], and produce enrichment in the organisms in contact with them, and further through the food chain. Zooming in and harming people, a small amount will threaten human health. Of course, heavy metals are not useless for human health. Some heavy metal elements are important enzymes, and proper intake is an integral part of maintaining the normal
survival metabolism of living organisms. However, if it is excessive, it will accumulate toxicity in the body.

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