Geological Environment Problems and Countermeasures of Shijiaying Mine in western Beijing

Zhang Zhiguo, Shen Naiqi, Wang Yingshuang, Li Yongcheng, Song Yanyan, He Tao

China University of geosciences School of Engineering and Technology
Beijing, China
e-mail: nqshen@cugb.edu.cn,nqshen@cugb.edu.cn

Abstract

Shijiaying, which is a small township in western Beijing, is rich in coal resources. Long-term coal mining has created enormous economic benefits, but also caused grievous geological environment problems, such as the deterioration of land resources and water resources, geologic hazards and the destruction of ecological landscape. Based on the analysis of the characteristics and hazards of the geological environment problems in mining area, we put forward a synthetic prevention scheme of the combination of engineering measures and biological measures. The engineering measures include slope cutting, earth-retaining and drainage works, and the biological measures are to green all available land with trees and grasses. After the countermeasures are taken, these hidden dangers will be cleared up to the utmost extent, and the ecological environment will be improved. Meanwhile, the economic development of local agricultural and forestry will be promoted.

Keywords: Mining area; Geological environment problems; Countermeasure;

1. Introduction

Shijiaying district is located in the western mountain area of Beijing city, which is rich in coal resources. The mining activities started from the 1970s, with coal mine more than 10 seats. According to the planning requirements of recent construction, all coal mines are closed in 2008. Mining for years in Shijiaying have caused grievous geological environment problems, such as surface collapse, land destruction, water resources deterioration, gangue pollution and ecological landscape destruction, etc. In addition, mine exploiting has greatly changed local ecological environment and living environment. According to the investigation and analysis, this article basically grasps the actual geological environment situation of Shijiaying area and the influence of mining development, and then discussed the existing environment problems. Finally the synthetic controlling scheme is proposed[1]. After that, the geologic hazards of
mining will be relieved and ecological environment will be improved. Meanwhile it will greatly promote the economic development of local agricultural and forestry.

2. General Situations of Shijiaying Mining area

Shijiaying mine is located in the west mountain of Beijing city, and it is about 70 km away from Fangshan district. The physiognomy of mining area belongs to hilly land, the elevation is 670 m to 990 m, and its relative relief is 240m to 320 m. The climate of mining area is continental monsoon, and the annual mean temperature is 4-11.7 °C, while lunar highest mean temperature is 11.1°C. The annual maximum rainfall is 1234 mm while minimum rainfall is 286.8 mm. Yearly average rainfall of flood season is 580 mm. The rainfall is rich in the period from June to August, and its rainfall takes up 75% of the whole year.

The mining area lies in Baihuashan syncline’s south-east limb of the west mountain folded downwarping. As a whole, the mining area is a monoclinal structure: the strike of stratum is NE-SW; the inclination of stratum is NW; the angle of inclination is 20º-30º. The strata appeared in mining area are coal-bearing strata composed of Majiapo Fm of Ordovician, Taiyuan Fm and Shanxi Fm of Carboniferous, Shihze Fm of Permian, Nandaling Fm and Yaopo Fm of Jurassic and Quaternary, while Yaopo Fm, Taiyuan Fm and Shanxi Fm is the main coal-bearing strata. There are five layers of coal in total, of which two layers spread stability. The thickness is about 0.8 m to 3 m, and the total reserves of about 2.5 million tons.

Residual-colluvial soil is widely distributed in bedrock and channel slope, containing collapse gravel and residual of weathering and erosion. The soil which is of asymmetric texture, unconsolidated structure, strong water permeability and weak stability is prone to glide and flow, and in sum it is of low shear strength. Groundwater is generally bedrock fissure water, stored at rock joint, stratification and fractures. When the groundwater flows from valley to channel, by the impact of mining, it will be seriously polluted.


3.1 Geological hazard

- Surface collapse and ground fissures
  Surface collapse found in mining area was aroused by exploiting coal resources. The exploiting left behind some mined-out areas underground that conducted the smash of stresses balance in superincumbent stratum which tended to give rise to distortion and sedimentation. Furthermore, it shaped low-lying zone at surface. Long-term exploiting of coal in study area have engendered vast mined-out areas, and caused transmutation of the hill, surface collapse and ground fissures (Figure 1, Figure 2). The survey shows that there are more than 17 collapse holes of different sizes, the largest is up to 898 m² of the total acreage of 2963 m². The surface collapse and ground fissures have damaged the land, threatened the safety of residents, and also destroyed the landscape.
  - Debris flow
  The occurrence of debris flow needs two necessary conditions: ① sufficient rainfall and convergence condition; ② loose accumulation, which is the source condition. The tailings, coal gangue, living garbage, fly ash and other wastes in the process of mining provide a source condition to debris flow. If these loose accumulations distributed in a mountainous area of convergence condition, once encountered rainstorm, will formed debris flow. According to investigation statistics, the local reserves of coal gangue reached a total of 650 thousand ton. The coal gangue piled in the channel or the mountain slope, mostly without tailings dam. All of these provide considerable conditions for the generation of debris flow; it may lead to a
serious debris flow hazard once rainfall condition is appropriate. In that case, the safety of 580 people and 437 houses on downstream will be affected.

- Landslide
  
- Mining will produce a lot of coal gangue and dregs to form waste heaps along mountain slopes. The gradients of slopes range from 38º to 40º and the heights range from 2 m to 5 m. The highest slope is up to 50 m. The slopes which have none protection measures are of unconsolidated structure and weak stability, and easy to slide. The calamity will threaten the safety of roads and local people. In addition, because of underground mining, surface fissures cutting and road repairing, the stability of mountain slope is reduced, thus it is easy to form collapse or landslide disaster in case of rainstorm, stream and earthquakes.

3.2 The damage to land resources

The destructional forms of mine exploiting directly to land resources are excavating land (Figure 3), subsiding land, misappropriating land and defiling land of mining “three wastes”. In addition, the change of tiny landform, geology and hydrology caused by mine excavating and collapse resulted in damage to drainage system and water supply system of land also add to the destructions. Thereby, the soil fertility factors have been exacerbating. Hydrocele of surface, soil stalinization, desertification, water and soil erosion are becoming more and more grievous.

![Figure 1. Ground fissures in Shijiaying mining area.](image1)

![Figure 2. Ground fissures in Shijiaying mining area.](image2)
Figure 3. Land excavating in Shijiaying mining area.

3.3 Pollution of gangue

In mining area, the waste heaps covers an area of about 17640 m² (Figure 4). The surface of coal gangues will be airslaked when they are piled up outside. Gangue dusts contain mercury, chromium, cadmium, copper, arsenic and other harmful element particles. If breathed in lung, it can lead to bronchitis, emphysema, pneumoconiosis and other diseases, more serious can cause cancer. In addition, coal gangues piled up outside caused serious pollution on the atmospheric environment, and brought adverse effect to “Blue Sky Plan” of Beijing. Especially in windy weather, dust granules on the coal gangues will be blew up and suspend, which will pollute the air. Furthermore, the black surface of coal gangue has strong heat absorptivity, which will make the temperature of gangue surface go up to 40 °C at noon in summer, thus mining area’s temperature will be heightened.

Figure 4. Land occupation of coal gangue heaps in Shijiaying mining area.

3.4 Pollution to water
Years of coal mining seriously changed the storage, transport and recycling of surface water and groundwater in Shijiaying area; moreover, the groundwater resources are exhausted. At present, the buried depth of groundwater in mining area is above 500 m, and the circumjacent wellspring is dried up. All of these can bring a serious impact on living and irrigation water of the local residents.

In addition, pit water produces in the process of mining include some toxic elements. Through the seepage or outward emissions, it can cause certain extent pollution to the surface and groundwater environment.

3.5 Pollution to natural landscape

The destruction of the gangue to mining landscape is mainly manifested in the natural scenery. The coal gangue mostly black piles up in mining area, the dust produced by gangue’s wind erosion fall over buildings and plants, and make it lose original color. It still reduces air cleanliness and illumination of land, and then makes mining environment turbidity. Above all, the calamity will threaten human health and the growth of animals and plants, the environment will be destroyed.

The pollution to soil, water and air of mining area broke pre-existing substance’s circulation between biocenosis and environment. Additionally, the accumulation of toxic and harmful substance, disturbing of noises and activities of production and livelihood, damage of general environment has been more serious. So, the environment that life-form lives by changed and deteriorated. Finally, the biological chain was broken and natural environment in mining area was unbalanced.

4. Controlling Scheme of Geological Environment

After the effects of ecological environment in Shijiaying mining area are assessed, the general controlling scheme can be organized with anticipated target and control measures. Based on the study area landform, present characteristics and problems of mine geological environment [2-3]. The study area is divided into 3 sections: gangue controlling area, slope repairing area and subside controlling area. Each area will take the comprehensive controlling scheme of the combination of engineering measures and biological measures (Figure 5, Figure 6).

Figure 5. Layout chart of engineering measures of the geological environment in Shijiaying mining area.
4.1 Gangue controlling area

Aiming at unstable slopes accumulated by gangues, slope cutting are taken to upside and retaining walls installed at the foot of slope, whose main function is to slow down gradient of gangue heap, boost its stability and eliminate the hidden danger. The degree of gangue piled cutting should be controlled at the below of 30°. With a solid structure, The retaining walls are formed with grouted stones and adopted trapeziform section (the height of 2.5 m, the coping width of 1.0 m, the bottom width of 3.5 m). Meanwhile, the foundation should be buried into mild airslaked bedrock or flinty soil layers within 0.5~1.0 m, which will satisfy the stability requirement.

For large-area of gangue heaps in the middle of mining area, controlling measures of rundle were adopted. That is: according to actual landform, tidy up tanglesome gangue heaps to form step slopes and platform. Ulteriorly, guarding walls can be built in front of slopes. For the small massif of severely deformed in southeast of the area, mountaintop will be excavated and stuffed to its southern lower road. Then, it can be tamped and leveled off to form a platform.

In order to eliminate debris flow hidden danger and drainage, a drainage ditch of grout-stone will be built in the groove of middle part. Surface water of slopes and groundwater of slope body will excrete to drainage ditch, which is propitious to the stability of guard walls. Drainage ditch adopted rectangular section, the design and checking were carried through by flooding standard of fifty year return period, its bottom width is 100 cm, and the depth is 100 cm. Its longitudinal gradient changed with terrain of groove. The checking results show that water-carrying flux satisfied flood’s excreting requests.

In addition, water-storage tanks will be constructed at upstream starting point and middle part of drainage ditch for the sake of collecting surface water to irrigate vegetation of subsequent revegetation engineering.

4.2 Slope repairing area

In order to eliminate the dangerous to the road by the unstable high slope from road cutting in the
mining area north side, the dangerous rock body and pumice stone on top of slope must be dug up cleaning. The grout-stone retaining walls of 1.5 m high will be built in front of slope; these retaining walls adopt trapeziform section, while the stability checking should meet the design requirements. In addition, spoiled dry stone pitching between northern road and main groove will be repaired and reinforced. Hillside land will be leveled off.

4.3 Subside controlling area

There are many subside pits and ground fissures in the eastern mining area, the hillside fragmented with weak stability. Ecological environment is badly destroyed. For this part, backfilling consolidation measures will be actualized. That is, using the gangue to backfill subside pits, reshape the slopes, and then earth up the surface with virescence engineering.

4.4 Vegetation recovery

After the controlling, it is necessary to perform environmental restoration in mining area. Learning from previous experience, we should plant amount of trees and grass. Plant roots can play a role in preventing soil erosion and slope reinforcement, so that restoration of ecological environment in mining, and also make full use of land resources. The specific planning scheme is: Six-row tiling protection should be taken on the slope after remediation, then plant climber and grass which has drought and frost resistance, such as vitex chinensis and bostonivy; Water retaining forests will be planted on berms between guarding walls, such as pine, cypress and Rhus typhina; Economic forests will be planted on the platforms that leveling off engineering and subside controlling engineering engendered, such as walnut tree, apple tree and jujube tree. It is plan to plant about 36.5 thousand trunk of tree, including 6250 economic trees. After preliminary statistics, the annual output of fruit is about 2.17 million yuan.

As a long-term work, later vegetation conservation needs to strengthen management. Early in the virescence, it should obdurate the hill, forbid browsing and mowing, decrease man-made sabotage furthest. After planting, it should momentarily observe diseases and insect pests of trees, once found, corresponding measures must be taken immediately. At the same time, the work of dry season water and fill the gaps with seedlings should be done.

5. Conclusions

Shijiaying area is rich in coal resources, long-term coal mining caused amount of geological environment problems, for example: damage of land resource and water resources, risks of geological hazards, pollution of gangue piled, destruction of ecological landscape and so on. Thus, the local ecological environment and living environment has been seriously damaged, and the economic development has also been severely restricted. For this reason, this article aims at the characteristic of the environment geology problems in study area. Subsequently, scientific and reasonable controlling scheme which combines engineering measures with vegetation restoration are put forward. It can maximally reduce the harm of the mine environment geology problems, and gradually eliminate all hidden dangers. After mine geological environment controlling is completed, it will restore agricultural and forest lands about 20 hectare. As a result, the controlling scheme greatly promotes the ecological environment improvement and the sustained development of the mining area.
References