Remote Sensing Monitoring Research of Mine Geological Environment in Southeastern Heilongjiang, China

Lingfen Guo1,2, Yongqing Chen1*, Shaohua Wang3

1 School of Earth Sciences and Resources, China University of Geosciences(Beijing), Beijing 100083, China;
2 College of Geographic Science, Harbin Normal University, Harbin, Heilongjiang 150025, China;
3 Heilongjiang Institute of Geological Survey, Harbin, Heilongjiang 150036, China

*Corresponding author’s e-mail: yqchen@cugb.edu.cn

Abstract: Southeastern Heilongjiang is abundant in mineral resources, among which coal mine is the most prominent one and is mainly underground mining, which has caused a series of geological environment problems. In order to find out the distribution and hidden dangers of mine geological hazards, land occupation from mining activities and the sources of environmental pollution in the mining area, the environmental investigation and monitoring of mine geological hazards were carried out based on remote sensing technology at Shuangyashan, Qitaihe, Jixi and Mudanjiang areas in southeastern Heilongjiang. The main mine geological environment problems in the study area are ground depression, collapse, landslide, debris flow, land occupation from mining activities, water pollution and solid waste pollution. The environmental investigation and monitoring of mine geological hazards based on remote sensing is obviously feasible. The results can provide decision support services for management departments to deal with sudden and major geological hazards.

1. Introduction
Since the turn of the industrial form in 2000, the mining industry had entered a period of rapid growth. The rapid development of mining industry provided important material guarantee for economic and social development, but also caused a large number of geological environment problems [1]. Southeastern Heilongjiang is rich in mineral resources, especially in coal mines. Geological disasters caused by mining seriously damaged the geological environment and ecology. The predecessors have carried out different scales of geological environment survey in Shuangyashan, Qitaihe, Jixi and Mudanjiang cities [2-4]. The survey was mostly carried out in mining concentrated areas, which failed to fully reflect the overall geological environment of the study area.

Traditional mine geological environment monitoring was unable to meet the needs of mine geological environment supervision in Heilongjiang Province [5]. Wang Xiaohong took Tangshan City as the research area to carry out mine monitoring based on remote sensing. She summed up the technical route of mine monitoring by remote sensing data of different spatial scales for different mineral species and different mining modes in different monitoring areas [6]. Remote sensing technology can quickly and accurately extract relevant information, and can exactly investigate and monitor the scale and area of geological disasters from a macro perspective. Moreover, the mine environment is constantly changing, so remote sensing technology can provide dynamic change data
and grasp the dynamic law of monitoring targets. It could provide decision-making basis for management departments to deal with sudden and serious geological disasters.

2. General Situation of geological environment
The study area is adjacent to Harbin in the west, Jiamusi in the north, Yanbian Autonomous Prefecture in Jilin Province in the south and Russia Far East in the east. Geomorphology is mainly composed of mountain, hill and plain. The overall topography is high in the southwest and northeast, low in the north and south, and gradually tilted from southwest to northeast. The southwest is Zhangguangcai range and Laoye ridge, the East is Wanda Mountain, the north is Sanjiang Plain, the southeast is Muling-Khanka Plain. There are many rivers and lakes in the area. The lakes are mainly Xingkai Lake and Jingpo Lake, which is rich in water resources. The study area is located in the humid climate zone of the mid-temperate zone, with four distinct seasons and uneven precipitation distribution.

The geological hazards occurred frequently in the study area, which mainly concentrated in coal mining areas. The ground subsidence is more concentrated and the subsidence area is wider. Coal mining caused destruction and occupation of large numbers of land resources, and has resulted in solid waste pollution, endangering human health and the sustainable development of mining industry.

3. Technical and method
3.1. Data source
The main sources of information for remote sensing comprehensive investigation and monitoring of mine geological environment in the working area are ZY-1 02C and SPOT-5. Combining various remote sensing data with GIS, by using computer image information enhancement technology and man-machine interactive interpretation method, investigative factors of geological hazards (landslides, landslides and debris flows) and their hidden dangers, land occupation from mining activities and mine greening were extracted from remote sensing images.

3.2. Investigation and monitoring contents
Based on high spatial resolution remote sensing data, it can obtain accurate data of investigation and monitoring utilizing image fusion, ortho-rectification, image enhancement and other pretreatment methods, used multi-objective and multi-level information extraction technology of remote sensing information, and carried out investigation and monitoring work at a scale of 1:50 000 of the study area, Southeastern Heilongjiang. The investigation content of geological hazards and their hidden dangers includes the types, distribution, scale, affected objects and scope, and whether there is a trend of further evolution. The objects of land occupation survey for mining activities include: mining pits being used and abandoned, transit sites, solid waste (gangue heap, dump), tailings ponds, etc. The survey content mainly includes the area and distribution of mine land occupation.

The study area covers three major coal cities of Heilongjiang Province, and the number of coal mines is large. Using the remote sensing technology can accurately interpret the type of land occupied by mines, the area occupied by land and solid waste, the scope of water pollution, etc. It overcomes the shortcomings of time-consuming and labor-consuming of conventional means and inadequate survey accuracy.

4. Results and conclusion
4.1. Geological disaster
Geological hazards and hidden dangers caused by mining activities can not be ignored. After decades of continuous mining in southeastern Heilongjiang, it had caused a series of geological environmental problems. The main types of geological hazards were collapses, landslides, debris flows, ground subsidence and so on. Through investigating, 1968 geological hazards were found, among which the ground subsidence, collapse and landslide were more prominent (Figures 1 and 2).
The geological disasters in the densely populated areas of the study area were mainly ground subsidence, which were basically caused by mining activities and resulted in the settlement and cracking of some residents' houses, the collapse of good fields, the destruction of roads, municipal, communications and power facilities. Among them, Shuangyashan has formed a 61.95 km² subsidence area. The coal mining subsidence areas were widely distributed, and the four old mining areas such as Lingdong, Lingxi, Baoshan and Sifangtai were particularly serious. The collapse area of Qitaihe was 119.01 km². The subsidence areas were mainly distributed in the emerging area. In recent years, there had been a significant expansion trend in the eastern area and the eggplant river area. The area of the subsidence formed in Jixi City was 206.28 km². At present, the collapse trend is still accelerating. The types of geological disasters in Mudanjiang area are mainly landslides and collapses. The ground collapse was only a small distribution in the north and southeast of the city.

The types and distributions of geological hazards in the above-mentioned areas were relatively concentrated, which was closely related to the main mining methods. Jixi, Qitaihe and Shuangyashan were the main coal-producing areas, and mainly underground mining, so these types of geological hazards were concentrated in those areas.

![Image](image_url)

**Figure 1. Statistical histogram of geological hazards in Southeastern Heilongjiang**

4.2. **land occupation from mining activities**

Shuangyashan, Qitaihe, Jixi and Mudanjiang are concentrated areas of mining activities. According to the survey data carried out in the above areas, mining activities in the four cities cover an area of 221.43 km², of which the stope area is 62.28 km², the transfer site area is 119.52 km², the solid waste area is 23.87 km², the mining building area is 9.36 km², and the tailings reservoir area is 6.4 km² (Figure 3). Statistics by administrative regions, mining activities in Qitaihe occupy an area of 42.12 km², mining activities in Shuangyashan cover an area of 52.15 km², covers an area of Jixi mining activity 78.4 km², Mudanjiang mining activity covers 48.75 km².

Shuangyashan, Qitaihe and Jixi are the three largest coal producing areas in Heilongjiang province. Underground mining is the main form of coal mining, and the main land occupation is transfer site. A large amount of solid waste (mainly coal gangue) generated during the process of coal mining occupies large amounts of land, which harms the surface and causes great damage to the environment.
4.3 Other environmental problems

Mining activities not only erode a large area of cultivated land, but also derive secondary pollution such as water pollution and solid waste, which endangers the mine ecological environment. Water pollution is more serious. The pollution sources mainly come from mine sewage in coal mine, wastewater from coal washery and sewage collected from rainwater after washing coal gangue, which resulted in long-term poor water quality. The water pollution in the study area has obvious regional characteristics, which mainly concentrated in the territorial waters near the coal washery. After the coal was washed, the sewage was discharged directly into the nearby river without treatment, resulting in turbidity of the river water, sediment of a large area of coal slag in the river bed, and serious pollution of water quality. At the same time, the discharge of coal mine sewage also causes different degrees of pollution of underground water. The main pollutants that cause excessive groundwater are iron, manganese, ammonia nitrogen and nitrite nitrogen. Influenced by primary and secondary pollution, the content of iron and manganese in groundwater in this area is relatively higher, of which the over-standard rate of iron and manganese is 46.1% and 53.9%. Some wells which ammonia nitrogen and nitrite nitrogen exceeding the standard mostly appear in the main towns and areas where human activities are more frequent.

Figuer 2. Distribution map of geological hazards in Southeastern Heilongjiang
5. Conclusion
Due to the influence of geography, geology and human activities, the geological hazards in the study area show a sustained growth in quantity, scale and scope. At the same time, mining activities in the area generate a continuous deterioration of the mine geological environment, which seriously affects the development of mining enterprises and endangering the safety of life and property of nearby residents. Therefore, it is of great significance to carry out remote sensing investigation and monitoring of geological hazards in mines of Shuangyashan, Qitaie, Jixi and Mudanjiang. It can not only improve the geological ecology and assess the impact of geological environment on social and economic development of the region, but also promote the social and economic development of the study areas.

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