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Impact of Mining Activities upon Environment in Panzhihua Region, Southwestern China

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Abstract: Mining activities have left huge uncovered slopes, large areas of gangue ground and extensive tailings dams. In this paper, we studied some impacts of mining activities upon environment in Panzhihua region, southwestern China. The environmental impacts include ecological destruction, geological disasters, environmental pollution, land damage, solid waste and occupational health effect in study area. The author suggested that local government should take some measure to reduce environmental impact in Panzhihua City. First, the countermeasure of reducing environmental impact is to set up ecological rehabilitation and environmental management system, which ensure the sustainable development of resources, environment, economy and society in this region. Second, the area needs to be monitored regularly for trace metal and other pollutants to forewarn urban eco-environmental safety.

Key words: Mining activity; Environmental impact; Pollution; Panzhihua region; SW China

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1 Introduction

Mining activities can have significant environmental impacts including visual intrusions, dust, noise, blasting, traffic and hydrology (Thornton, 1996; Ripley et al., 1996; Kwolek, 1999). The processes of mineral extraction, processing, smelting and refining can never approximate to becoming environmentally neutral, but the areas of impact can be ameliorated (Kwolek, 1999; Klukanova & Rapant, 1999). The regions where mining activity was present a long time are potential candidates for a wide diffusion of pollutant elements in the environment (Allan, 1995; 1997). Hence, these areas are the target of detailed environmental geochemical surveys, which have to take into account both the distribution of these elements in relation to the exploration and treatment centers, and the designation of the different areas for land use (Boni et al., 1999). Geochemists and geologist working with environmental assessment teams have multiple missions (Siegel, 1995; 2002): (1) to predict potential pollution problems that could occur; (2) to resolve newly identified or suddenly high profile short-term or long-term contamination problems to minimize the impact on the living ecosystem; and (3) to evaluate remediation that might be proposed in light of the practical and future impacts on the environment.

There have been extensive metal and industrial mineral mining activities in China, resulting in serious impacts on the environment. To study the environmen-

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tal impact of mining activities, we selected Panzhihua mining base as a case study.

2 Characteristics of Mining Activities

The study area extends from 26°30′N to 26°40′N and 101°30′to 102°00′E. Panzhihua, an important industrial and mining city with abundant mineral resources, located in southwest of China. The giant Panzhihua Vanadium-Titanium Magnetite [$Fe(V,Ti)_3O_4$] deposit, located in the southern part of the NS-trending Panxi rift valley, along the Jinsha river (a tributary of the Yangtze River) in Southwestern China, provides 20% of the Fe, 64% of the V and 53% of the Ti for China. The mining camp includes 6 large-scale iron deposits hosted in basic-ultrabasic intrusions, numerous medium-size coal, clay, dolomite, limestone deposits, and minor graphite, manganese and barite deposits (Table 1). Production facilities include a large steel manufacturing mill and a steel rolling mill. The extensive mining and processing activities have caused major environmental impacts (Ni et al., 2001; Teng et al., 2000, 2001).

Table 1 Typical Mine in Panzhihua Region

Mine	Location	Scale
Coal	Baoding	Large
	Hongni	Middle
	Huaping	Small
Iron	Panzhihua, Dahe, Baima, Hongge	Large
	Xinjie	Meddle
Limestone	Longdong, Baguanhe, Dahuoshan, Hongshiya	Large
	Daxiaojing	Middle
Clay	Laluoqing	Large
	Dahuoshan, Ertan	Middle
Diatomite	Miyi Zhongliangzi, Tianhangou	Middle
Dolomite	Daxiaojing, Guanyinya, Panzhihua	Middle

The mining activities have caused huge uncovered slopes, large areas of gangue ground and extensive tailings dams. 11.50 million tons of Fe ore is mined per year, and more than 680 million tons of excavated ore and gangue, and 220 million m^3 of tailings re-serve have been deposited near the Jinsha River. It is less than twenty kilometers from main mining area to Jinsha river. Thus there is severe threat of heavy metal pollution both in the mining area and further down stream towards the Yangtze River (Ni et al., 2001; Teng et al., 2000, 2001).

3 Environmental Impacts

3.1 Ecological destruction

The eco-environment was damaged because of mining activities and population increasing in study area. For example, the vegetation was destructed and virgin forest was felled. It was estimated that the forest coverage is descending from 65% in 1965 when the mining was established to 30% in 1990s in Panzhihua area. While the industrial three waste' effluent and other physical and chemical pollution has been impacting the ecological system safety (Teng et al., 2000). Especially, hot pollution from iron smelting threat cycad which is an potentially extinct plant.

Mining activities therefore threaten the ecology of the Jinsha and Yangtze Rivers. Soil erosion rates of the Neocene-Quaternary Xigeda Formation are between 5 000~8 000 tons/km^2 per year. Soil loss in the Panzhihua mining area is 3.7 to 5.9 mm per year, significantly higher than that in areas where there is no mining activity. Thus, mining activities distribute much of the soil and unconsolidated sands subsequently found in the water of the Yangtze River. In 1999, the suspended particle content of the water of the Jingsha River within the mining area was 224% to 289% over acceptable amounts (Ni et al., 2001).

3.2 Geological Disaster

The mining activity is located along the eastern margin of the Tibetan plateau, a tectonically active region. Rapid geological events such as debris flows, landslips and large-scale subsidence take place repeatedly in the area. Mining activities have accelerated these geological catastrophes. There are many complicated active and inactive structures in study area because Panzhihua region is located in Pan-Xi rift. The mainly geological disasters are landslip, debris and collapse. In rainy season, some landslips usually occurred in coal mine, duns piles, dumping waste and slag piles.

3.3 Land Use and Soil Pollution

It was estimated that there was a total of 214.8

km^2 land use for mining activity (Table 2), and the land square of V-Ti-Magnetite mining district and coal mining district was 38.0 km^2 and 168.0 km^2 respectively (Table 2). It was investigated that some steps were not taken to carry out land reclamation and prevent soil pollution, so the soil quality was deteriorating and then wasted much more land resources.

The data in the table 3 revealed that the topsoil samples were showing high values for some trace metals such as V, Ti, As, Cd, Co, Cr, Ni, Cu, Pb and Zn (Table 3). In different mining area, the concentration of the element V, Ti, As, Cd, Co, Cr, Ni, Cu, Pb and Zn was higher than that of soil background concentration of China, so the topsoil was contaminated by mining activities in study area (Teng, 2001).

Table 2 Land usage square of mining district in study area

Mining district	Land Square (km^2)
V-Ti-Magnetite mining district	38.0
Dumping soil	1.0
Tailing pile	3.5
Coal mining district	168.0
Coal-washing	0.5
Duns pile	0.3
Limestone mining district	3.1
Clay mining district	0.4
Total	214.8

Table 3 Some selected elements concentration in topsoil in study area (mg/kg)

	As	Cd	Co	Cr	Cu	Zn	Ni	Pb	V	Ti
Coal mining district	15.13	0.31	16.98	89.76	41.51	112.06	50.14	37.99	113.50	3600
V-Ti-Magnetite mining district	12.94	0.26	18.24	97.82	49.05	85.60	52.03	37.50	116.50	4000
tailing dam district	16.53	0.28	19.44	107.60	49.96	85.92	66.40	37.42	125.10	3800
V-Ti-Magnetite smelting district	12.94	0.14	11.99	72.45	32.14	64.94	38.84	24.70	86.19	3400
SBCC*	11.2	0.097	12.7	61.0	22.6	74.2	26.9	26.0	82.4	3800

SBCC: Soil Background Concentration of China, data source: Wang & Wei, 1995

3.4 Solid Waste

Since 1965, huge solid waste including steel slag, tailing and duns from mining activities was discharged in study area. A total of 0.68 billion tons solid waste was from some mining districts (Table 4). There were many potential toxicity matters in these solid wastes. These solid wastes were leached by surface water and precipitation, some potential toxicity elements can be released into environment. The concentration of Cr_2O_3 is 0.105% in slag (Table 5), once it was leached into the environment to cause Cr pollution. And the concentration of some heavy metal was very high in the tailing in magnetite mining area (Table 6), so it was a pollution source. In addition, the solid waste pile may collapse to become hazards.

Table 4 Solid waste in study area from some mining districts

Mining district	Solid Waste (billion tons)
Zhu V-Ti-Magnetite Mine	0.402
Limestone mine	0.02561
Coal mine	0.01500
V-Ti-Magnetite Processing	0.1104
Coal-washing	0.01560
Other mining factory	0.11
Total	0.68

Table 5 The primary chemical composition of the slag produced by a converter in study area (%)

V_2O_5	P_2O_5	SiO_2	TiO_2	Al_2	Cr_2O_3	FeO	MnO	CaO	MgO
6.25	0.374	10.05	5.33	1.69	0.105	10.66	1.54	51.23	4.55

Data source: Qiu, et al., 2002

Table 6 Some selected elements concentration in tailing of mining area (mg/kg)

Cu	Zn	Cd	Cr	Pb	Co	Ni	Ti	V
469	237	4.00	50.0	37.5	300	216	18900	143.5

Data source: Li, 1999

3.5 Water Pollution

In 1997, there was 50640100 tons of waste water resulting from industrial and mining activities. From 1996 to 2000, we selected the two monitor profiles that are nearby the V-Ti-Magnetite processor and smelting factory respectively to study waster pollution. The concentration of Pb, Cd, Cu and Mn in Jinsha river nearby the V-Ti-Magnetite processing and smelting is much higher than the water background of Jinsha River (Table 7), so mining and smelting activities have been polluting the surface water, especially heavy metal pollution.

Table 7 The total concentration of some selected elements in Jinsha River

	Pb	Cd	Cu	Mn
Profile Nearby the V-Ti-Magnetite Processor (mg/L)				
1996	0.014	0.0002	0.026	0.4036
1997	0.005	0.0001	0.009	0.1087
1998	0.025	0.0003	0.049	0.7340
1999	0.035	0.0002	0.034	0.3670
2000	0.015	0.0001	0.028	0.3700
Profile Nearby the V-Ti-Magnetite Smelting Factory (mg/L)				
1996	0.021	0.0004	0.033	0.4515
1997	0.009	0.0001	0.016	0.1298
1998	0.031	0.0004	0.059	0.7860
1999	0.042	0.0002	0.044	0.4730
2000	0.026	0.0001	0.053	0.4860
Water Background Concentration of Jinsha River (μg/L) (Zhang et al., 1996)				
	1.26	0.074	3.17	47.6

Data source: Environmental Protection Agency of Panzhihua City, 2001

The mine drainage of V-Ti-Magnetite mining area has been analyzed by others (Table 8). The concentration of Cu, Zn, Pb and V has high value in different mining area and become some important pollution sources.

The quality of groundwater has been degraded in mining area (Table 9), and its characteristics are high-mineralized degree and high concentration of ion.

Table 8 Some selected elements concentration in filtering water from mining effluents (mg/L)

	Cu	Zn	Pb	V
Waste water from mining				
Pre-monsoon	0.022	0.011	0.061	0.004
Post-monsoon	0.008	0.157	0.045	0.009
Overflowing Water in tailing dam				
Pre-monsoon	0.015	0.010	0.037	0.002
Post-monsoon	0.008	0.121	0.048	0.003
Waste water from processing				
Pre-monsoon	0.055	0.010	0.030	0.004
Post-monsoon	0.040	0.167	0.035	0.003

Data source: Yang and Liu, 1995

Table 9 Analyzed result of groundwater in V-Ti-Magnetite mining area

	SO_4^{2-}	Ca^{2+}	Mineralized degree	NO_2^-	NO_3^-
Groundwater	173.65	105.4	511.8	0.073	10.42
Groundwater in tailing dam	302.19	139.6	836	0.002	0.04

Data source: Li, 1999

The data in the table 10 revealed that the stream sediment samples were showing high values for some trace metals such as Ti, V, Cr, Mn, Zn, Cu, Pb and As. Some of the elements in grain size 0.125mm have contents in the range of titanium 0.37 ~5.28%, vanadium 101.20 ~690.90mg/kg, chromium 82.60 ~302.20 mg/kg, manganese 0.06% ~0.82%, zinc 33.70 ~250.10 mg/kg, copper 29.20 ~231.40 mg/kg, lead 10.10 ~64.30 mg/kg and arsenic 7.90 ~19.20 mg/kg (Table 10). The heavy metal distribution show that the contaminated sites are located in V-Ti-magnetite sloping and smelting, gangues dam (Teng et al., 2003). Thus the anthropogenic sources of heavy metals are mainly waste rocks (dumping ore rocks or gangues), smelting slag, tailings and wastewater from the mining, processing, extracting and smelting activities in the study area. The pollution sources of heavy metal are rock weathering, smelting slag, dust, tailings and mine drainage in the study area (Teng et al., 2003).

Table 10 Some selected elements concentration in stream sediment (grain size =0.125mm) in study area (n =87)

	Ti(%)	V (mg/kg)	Cr (mg/kg)	Mn (%)	Zn (mg/kg)	Pb (mg/kg)	As(mg/kg)	Cu (mg/kg)
Mean	1.03	199.11	108.45	0.14	93.09	25.84	14.74	58.41
Max.	5.28	690.90	302.20	0.82	250.10	64.30	19.20	231.40
Min.	0.37	101.20	82.60	0.06	33.70	10.10	7.90	29.20
Median	0.57	135.95	97.80	0.12	80.90	26.40	14.45	47.80
Stdev	0.96	122.58	32.18	0.12	46.01	7.87	2.33	29.87

Data source: Teng et al., 2003

3.6 Air Pollution

There are two types of air pollution: physical pollution and chemical pollution (Teng et al., 2000). Physical pollution includes dust and fly-ash from mining, exploding, transferring and smelting. Chemical pollution includes poisonous, organism, harmful and acid gas from mining and smelting. The frequency of acid rain is 41% in study area. In 1997, the total amount of pollutant gases is estimated at 84.8 billion m^3. From 1996 to 2000, measured abundances of SO_2, NOx, and TSP (total suspended particle) in the air are regularly more than those permitted by government in coal-mining area and smelting area in Panzhihua region (Table 11). Likewise, sink dusts are very heavy in smelting area, coal mining area and processing area (Table 12). Some selected lithogenic elements such as S, K, Si, Al, Ti and Ca in aerosol-have high concentration in coal mining area, while some selected heavy metals such as Cu, Pb, Zn, V, Co, Mn and Ni in aerosol have high concentration in iron mining and smelting areas (Tang et al., 1991; Teng, 2003).

3.7 Healthy Risk

The Mining activities can cause some healthy risks in study area. People who exposed to the mining environment had heavy healthy problems such as occupational diseases and damages. The occupational healthy investigation result showed that it is related to mining activities and mining environmental pollution, for example, 74.37% (1256 out of 1689) pneumoconiosis is resulted from mining industry (Li, 1994).

Table 11 Air pollution monitoring result in study area from 1996 to 2000 (mg/m^3)

	1996	1997	1998	1999	2000
Coal—mining area					
SO_2	0.142	0.102	0.147	0.090	0.078
NO_x	0.097	0.109	0.095	0.048	0.028
TSP	0.489	0.458	0.395	0.397	0.396
Smelting area					
SO_2	0.066	0.084	0.047	0.053	0.034
NO_x	0.068	0.095	0.077	0.037	0.024
TSP	0.366	0.331	0.296	0.275	0.260
Clear area					
SO_2	0.056	0.084	0.022	0.021	0.013
NO_x	0.021	0.034	0.017	0.020	0.016
TSP	0.186	0.191	0.127	0.180	0.166

Data source: Environmental Protection Agency of Panzhihua City, 2001

Table 12 Sink dust in study area (ton/km^2 month)

	1996	1997	1998	1999	2000
Smelting area	28.9	32.0	25.1	29.1	30.5
Coal mining area	28.6	35.3	27.7	28.4	24.3
Processing area	7.2	11.5	18.0	11.3	10.5
Clear area	3.5	4.2	4.4	3.2	3.3

Data source: Environmental Protection Agency of Panzhihua City, 2001

4 Discussions and Conclusion

The large-scale mining activities polluted the environment and destroyed the ecological balance in Panzhihua mining area. The environmental impacts include ecological destruction, geological disasters, environmental pollution, land damage, solid waste and occupational health effect in study area.

The author suggested that local government should take some measure to reduce environmental impact in Panzhihua City. First, the countermeasure of reducing environmental impact is to set up ecological rehabilitation and environmental management system, which ensure the sustainable development of resources, environment, economy and society in this region. Second, the area needs to be monitored regularly for trace metal to forewarn eco-environmental safety.

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