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ENVIRONMENTAL AND GEOETHICAL PROBLEMS IN THE MINING AREA OF ERDENET (CASE STUDY)

Introduction

Mining is the most important industry in Mongolian economics. Mongolia possesses significant reserves of coal, copper, gold, tin, and uranium. Gold mining generates of about 70% of foreign currency. The country's copper reserves at Oyu Tolgoi alone are second only to Chile's total copper reserves, and Mongolia's inferred uranium resources are expected to be second only to those of Australia.

Most of the mining operation (more then 150 mining companies) are the surface mining from placers, open-cuts and open-pits which requires excavation and washing of metal bearing strata resulting in significant landscape disturbance. Mining of copper-molybdenum ore results in high energy consumption and environmental problems arising for tailing storage, dust and water contamination. Environmental impacts associated with mining activity are:

(1) turbidity of surface water resulting from the dredging of river sediments and the discharge of ore processing residues;
(2) potential acid mine drainage and sulfide bearing tailings resulting from the base metals and gold mining;
(3) changes of hydrogeological characteristics and water quality by dewatering; and
(4) degradation of air quality by traffic.

Apart from major national and international companies, gold mining was widely practiced by so-called "ninjas" (artisanal gold miners) from the late 1990's and early 2000's, and is still going on today. The total number of people involved in part-time or full-time artisan activity is in the order of tens of thousands, a staggering figure if compared to the total population: some sources record more than 100.000 people, including not only men but also their families: women and children of any age. Local and national authorities, with the help of NGO's and international agencies, have attempted from the mid-2000's to stop bad practices, and to introduce safe methods for gold recovery. However, monitoring the degree of environmental contamination in the country is a fundamental task for the future.

Case studies in areas of intensive mining operation: Erdenet Cu-Mo deposit, gold mine Boroo, and South Gobi are presented as an example of environmental impact.

Results of environmental study

Erdenet Cu-Mo mine: Erdenet Cu-Mo-porphyry deposit exploited since 1978. Usually porphyry deposits are mined by open pit method, which exposes sulphide minerals to the surface weathering condition, accelerating natural chemical weathering process and releasing acid, metals and sulphate to the environment. The Erdenet is an open pit mine. Environmental study around the Erdenet mine shows that element distribution in soil and river water varies by distance and direction from mine. About 5 km vicinity of the mine is much more polluted by Cu and Mo, and ca. 35 km east and south-east side is obviously polluted. Possible reasons of Cu and Mo enrichment in east, southeast side of mine could be explained by dominant wind and stream directions from west, northwest to east, southeast.

Cu/Al and Mo/Al distribution depends on direction and distance from the mine site, e.g., Mo/Al is higher than Cu/Al in near places to the mine and this behavior changes in reverse in far distanced area. This can be explained by element behavior, soil characteristic and also relation between element and soil as well. Heavy metals pollute only soil surface depending on soil characteristics and dry climate with low annual precipitation (average annual precipitation is 250 mm). Cu, Zn, As, Mo, Mn and Fe are higher in Erdenet and Khangal river waters near the Mine, even though all are not exceeded than standard. Mo shows variable distribution if compared to Cu because Mo is more soluble in alkaline soil than Cu. Increase of Cu and Mo correlation in soil than source (rock) indicates later mining effect and loss of correlation in river water is due to solubility difference of those elements. Cu and Mo show a correlation in Erdenet Porphyry Association rocks indicating their magmatic source. Cu and Mo correlation coefficient increased in soil than rock signifying later effect, e.g. mining activity. Summarizing this study it is possible to conclude that the environmental impact of the Erdenet mine is relatively low.

Boroo gol river area. Boroo gol valley is an old gold province. The exploration and mining in the Boroo gol valley began after the beginning of last century by the International Mongolor Company in 1903-1921. Case study in the Boroo river area has been carried out by Geomin Jihlava together with Department of Geology, Mongolian University of Science & Technology.

Factory pans broken out due to loss of mercury at bottom of Boroo gol area in 1956 and after that time contamination by mercury in environments of Boroo gol area has occurred. Soil layers of alluvium sediments, clays, and tailings are contaminated with mercury. Mercury contamination in alluvium sediments is 8 times higher than accepted amount (0.15 ppm), 65 times higher in clays and 270 times higher in tailings. The mercury contamination at Boroo river area has been more polluting in neighboring area cause of water flow and human opportunity. The distribution of mercury contamination is related to the geomorphology. It is accumulated in meander zone.

14 females and 8 males have participated in our research. Mercury content in urine of 50 percent of females and 87.5 percent of males was 2-4 times higher than accepted amount (25 mg/l). Mercury content of human hair around Selenge river was 3-4.6mg/kg, while it was in accepted amount (1mg/kg) of 1mg/kg around Boroo river. As about the potherbs, the

mercury content in potato is showed from 3 to 4 times higher than accepted amount (0.03 ppm), in carrot 0.3 times higher. Therefore it is necessary to make control of mercury contamination in the potherb. Mercury contamination of grass is 3-6 ppm. It is shown that it is from 3 to 6 times higher than the accepted standard. But in the flesh of animals, mercury contamination is relatively less. Mercury contamination of fishes is shown to be from 3 to 4 times higher than the acceptable amount (0.3 g/kg).

The volume of mercury contained in clay layer of gold bearing rock was measured as 9415 m3 and 9907m^3 in waste after gold washing. So it would require 966 days to wash out mercury from total of 19312 m3 soil at a rate of 20 t/day.

South Gobi. Reconnaissance survey in cooperation with Trieste University done in two basically different types of terrain: a southern desert to semi-desert one, and a northern vegetation-rich, mountainous district with surface drainage. A review of the literature on mercury pollution worldwide shows that studies on mercury dispersal in the environment are mostly done for tropical areas: it seems that no serious research on the mercury cycle so far has been done in areas characterized by arid climate with a strong temperature excursion, in an intra-continental environment such as the South Gobi.

Mining activity in this area has the same pattern: after identification (mainly through metal detectors) of gold occurrences (generally found in more or less Au-bearing sulfides of quartz-rich seams or veins cm- to dm-thick) in a hard rock matrix, excavation is done by digging trenches (photo) or holes up to a depth of some meters. Holes and/or trenches were, and still are, connected sometimes underground, causing in some cases collapse of the tunnels and producing severe injuries or even death of miners. The rough, fragmented material extracted, when significantly rich in metal, was brought in various ways to the nearest water well, where it was crushed to a fraction of a few mm or even less by machines provided temporarily by private owners. Water was essential in the crushing process. Water and mercury were then added to the pulverized material, thus creating the gold amalgam to be separately heated for gold recovery. Mercury was therefore largely volatilized, but a substantial part was trapped in the rock powder (tailing), and sometimes also recovered for further recycling. The tailing resulting from rock crushing and mercury treatment is locally called “schlam”: it is an incoherent, whitish to yellow powder, easily dispersed in the surrounding area by wind and/or by the rare rains and storms. Miners used to collect the “schlam” in mounds near the water wells.

According to officials of the provincial Administration in Dalandzadgad, 11 out of the 15 “soums” (municipalities) in the province have witnessed “ninja” activity starting from 2001, and in 9 of them contamination of mercury (in some cases also cyanide) has been recorded in the last 5 years. Awareness of health risks by the miners dates back to 2004.

The number of water wells in the soums of the province is of course variable, but the figure is generally in the order of 100. In Hanbogd soum, one of the visited districts, 40 deep-water wells (from 50 to more than 100 m deep) are contaminated by mercury. It is reminded that camels (a major living resource of local families) drink about 50 liters of water per day. The National Emergency Management Agency in the year 2006 decided to stop the use of toxic

substances, by collecting the tailings in a deposit located in Dorvoljin Teeg Tolgoy near the main road to China. The crushing machines (38 from the Hanbogd district, 68 from the whole province) were shipped to Darhan in the north, to be destroyed

The Gurvansayhan National Park, one of the largest in Mongolia, is an area well known for its magnificent sceneries of exceptional geological and cultural value. It is an ideal site for the establishment of a Geopark according to the requirements of UNESCO and IUGS (International Union of Geological Sciences), but the process will require fulfillment of actions related to a series of environmental, historical, socio-economic and administrative matters. A careful monitoring of type and extent of pollution is especially necessary for any area candidate to Geopark status. In the case of the Gurvansayhan Park, human activity such as artisanal gold mining may well represent - besides the traditional nomadic life advertised for present-day tourist tours.

The survey has indicated that awareness of the danger of mercury and cyanide use in gold recovery is widely known by local families, by soum population and by the ninjas themselves.

However, it seems that there is no knowledge of the mobility of toxic substances, and of their log-range effects on the environment at large. Furthermore, neither evidence nor information has been found of the possible existence of other very harmful toxic substances, such as arsenic (an element which is in many cases, depending on mother-rock composition, is part of the gold-bearing minerals, and is strongly mobilized through metallurgical treatment). Bad (harmful) practices are probably still carried out by ninjas in far away places, where local and national authorities have no constant or easy access.

Summary and future goal

The final outcome of the case studies indicates that a project based on accurate monitoring of the extent, both qualitative and quantitative, of environmental pollution in selected districts could be profitably organized and also welcomed by local people. Such an enterprise may well serve as a pilot venture to be systematically applied to other areas of the country. In all visited districts, in South Gobi, systematic monitoring of mercury contamination (and of other possible pollutants) in water, soil and plants is absolutely necessary in order to secure adequate information on the actual situation. Sampling and data evaluation according to international standards should be provided taking into account seasonal and possibly yearly variation, and special attention should be directed to the cycle of mercury in arid or semi-desert areas. Only after provision of factual information any undertaking for the protection of the environment will be successful.

Mongolia’s natural resources are fragile and stressed by human activity, harsh winters, hot summers, and low rainfall. For over a decade, the country has been making the transition from a centrally planned to an open market economy. During this transition, its natural resources have been heavily exploited. For example, deforestation rates have risen since the mid 1990s from around 40,000 ha annually to around 60,000 ha. Now only 12.4 million ha of

closed forest remain. The county's deteriorating environmental situation is exacerbated by irresponsible vested interests, poor coordination among ministries and agencies, inadequate monitoring of natural resource conditions and weak enforcement of environmental regulations.

The Government of Mongolia has enacted a series of environmental laws, expanded its system of nature reserves, and started to invest in energy-efficient technologies and pollution abatement schemes. In addition, the Government is trying to mainstream environmental concerns into development, and is working with international organizations and civil society to promote environmental awareness. The World Bank is collaborating with WHO on air pollution/health analysis and produces annual Environment Monitors, the first of which was focused on the overall environment, the second on land resource management and the third on urban environment services. The World Bank is also providing technical assistance to the Ministry of Nature and Environment on environmental assessment, regulation and enforcement.

Therefore it will be very useful to establish a Working Group in Geoethics and together with Mongolian Geological Society to bring any IUGS and International Community experience in Geoethics Audit to Mongolia.