

Environmental Issues related to Primary Mercury Mining in KYRGYZSTAN

Technical Assessment 2009



Technical Assessment on Environmental Issues related to Primary Mercury Mining in KYRGYZSTAN

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Mercury production at Khaidarkan

Lead authors: Viktor Novikov and Christina Stuhlberger

Co-authors: Professor Abdulhamid Kayumov, Kanybek Isabaev, Valentin Bogdetsky

Contributors: Otto Simonett, Brenda Koekkoek, Tatjana Terekhova, Bruno Frattini, Ari Makela

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Produced by Zoï Environment Network and GRID-Arendal, September 2009



DISCLAIMER: Robust and reliable technical and environmental data being difficult to obtain on past and current mercury mining operations in Kyrgyzstan, the assessment report has used data from various sources and in some instances the data is incomplete. Any views expressed in the document do not necessarily reflect the views of UNEP.

For comments and information please contact christina.stuhlberger@zoinet.org and viktor.novikov@zoinet.org

Executive summary

Project background

This report is part of the overall Kyrgyzstan Primary Mercury Mining Project funded by the Government of Norway, Switzerland and the United States of America and being carried out as a partnership between UNITAR, UNEP, and Zoï Environment Network.

Reducing the supply of mercury has been identified as a priority area by the United Nations Environment Programme (UNEP) Governing Council, which considers primary mercury mining as an important activity to be addressed in order to reduce global loadings of mercury to the environment in the future. It is considered highly likely there will be global controls in place on mercury within a 10 year time frame.

Kyrgyzstan is the last remaining major supplier of primary mined mercury to the international marketplace. This project was initiated to assist Kyrgyzstan to address the possible phasing out of mercury production at the Khaidarkan Mercury Mine. As part of the overall project, a feasibility study is being undertaken aimed to facilitate, with further support from a planned consortium of donors (including the US, GEF, World Bank, Asia Development Bank and others), the eventual cessation of mercury mining activities in an environmentally and socially sound manner.

The main findings of the Technical Assessment address two priority areas: i) environmental impact of past and current mercury production and ii) the technical conditions and the economic viability of mercury production and possible industrial alternatives.

Environmental impact

Based on expert interviews, field research and a screening sampling campaign, the assessment concludes that the area around Khaidarkan plant, comprising Khaidarkan town and adjacent agricultural land as well as natural waterways is characterized by elevated mercury concentrations. The mercury levels in agricultural soils, river sediments, shaft water sediments and ambient air frequently exceed the national environmental standards of Kyrgyzstan. Due to technical limitations, chemical forms of mercury could not be specified.

There are very limited environmental protection measures in place, while instrumental monitoring and quality of environmental reporting is inadequate in view of the identified and potential hazards.

Technical equipment at the site is largely outdated and requires maintenance. Relevant emission sources comprise:

- Mercury smelter; in particular emissions from the rotary kilns, stack emissions (pollutant concentrations essentially vary depending on smelter operation and weather conditions) and process water from the mercury precipitation process.

- Slag heaps and sludge sedimentation ponds; wind and water erosion of mercury-rich material and uncontrolled accessibility.
- Tailing ponds; wind and water erosion, dust formation (especially in warm and dry seasons), water seepage and uncontrolled accessibility.

Re-volatilization of mercury deposited in the natural environment also contributes to elevated mercury levels in ambient air and river sediments. Even if mercury production stops in the area, this source for pollution will remain.

A limited number of studies suggest that in the past there were likely impacts on human health resulting from mercury production in the Khaidarkan area. Recent data indicate that in particular the immune systems of children appear to be weakened by the elevated levels of mercury in the environment. Some categories of workers are exposed to elevated occupational health risks.

Mercury production

Production levels at Khaidarkan plant seem to decline due to depletion of mercury ores in the developed areas and attenuation of primary mercury production is considered imminent by the mine management as stated in the Khaidarkan Business Plan for Cement Production (2005). It is estimated that explored reserves of mercury will be sufficient for approximately five to seven years of operation. In 2007, almost 50 per cent of the mercury produced in Khaidarkan originated from secondary sources such as chlor-alkali wastes imported from Russia. The company foresaw continuation of this practice to stabilise mercury production which has been hampered by technical difficulties but no new contracts for mercury-rich waste materials import were concluded in 2008 which is reflected in the lower production figures compared to 2007. Other products of the mine are fluorspar and antimony concentrates. The production cost of fluorspar concentrate is twice the market value of the product. In the past, profitable mercury sales balanced out the negative income from such activities. Since the company created a deficit in 2008, it was decided to cease this operation and to focus on exploratory works to strengthen the mercury and antimony business.

Mining since independence has been largely based on exploratory work done during the Soviet era when large resources were allocated to geological survey. Even though it is known that significant mercury reserves are located at greater depths or at abandoned mining sites, the capital investment required to make these resources available is limiting their exploitation. In 2009 the Khaidarkan plant requested 20 million soms (about US\$0.5 million) from the Government for geological survey and other development needs.

In June 2009, a major failure in the pumping system at the main mercury producing shaft of Khaidarkan occurred, which reportedly led to the flooding of several lower levels of the shaft and suspension of mining operations there. Due to lack of funds, the plant management declared that it cannot fix the problem and appealed to the governmental support.

Mercury export

The destinations for and applications of mercury produced in Khaidarkan remain unclear: a number of export countries and trading pathways have been discussed, but none could be officially confirmed. Kyrgyz representatives at the National Forum on the Action Plan to address Primary Mercury Mining and its Impact on Environment held in July 2009 in Bishkek indicated that China is the major export destination of Khaidarkan's mercury. The Kyrgyz Ministry of Industry, Energy and Fuel Resources and the Khaidarkan management report that in 2007-8, around 80-90 per cent of mercury products were purchased by foreign firms and 10-20 per cent by CIS countries (Russia, Azerbaijan). Local experts indicated that a small fraction of the mercury remains in Kyrgyzstan where it is used for artisanal gold mining, predominantly in central and southern regions.

Economic conditions of Khaidarkan plant

Due to high operational cost, technical difficulties, constraints in feedstock supply and lack of professional staff, the company results have been struggling over the past years. In particular the high cost for energy (electricity and gas) which amount to about 45-50 million som (approximately US\$ 1 million) per year, make up 30 to 50 per cent of the total operational cost. It has been stated by various company and government representatives that the mine is self-sustaining and no subsidies are given. However, the department on regulation of the fuel and energy complex at the Ministry of industry sets the preferential tariffs for electricity consumed at Khaidarkan (natural gas has no benefits). According to the mine, the company pays 1 som (about US\$0.3) per 1 kWh. The reduced tariff is 30 per cent lower compared to common prices for industrial consumption. It is explained that this kind of subsidized price is applied because Khaidarkan supplies pumped water for the local community used of irrigation and households (non-industrial electricity consumption). Reported liabilities consist for a large part of energy debts that reportedly have caused recent rumours about the plant being pledged to foreign companies.

Local conditions

The Khaidarkan mine is still strongly supported by the general public in the area and by institutions unconnected with the environment. However, the effects of the economic crisis, recent cash flow problems as well as technical difficulties surfacing over the past months appear to open up possibilities for discussing alternative development strategies.

The number of employees has decreased recently. In 2007, 865 people were directly employed by the mine, including about 100 management personell. The number went down to about 750 people in 2008.

The mine has indicated that one of the handicaps in maintaining stable production is the lack of professional staff. Most skilled and experienced workers have left or migrated to other districts of Kyrgyzstan or CIS countries where higher salaries can be obtained.

Economic alternatives

Industrial opportunities for economic diversification comprise gold mining, cement production, construction industry, bauxite mining and aluminium production, bentonite extraction and production of fire resistant bricks. Each of these options requires thorough analysis before clear recommendations can be made but it has been concluded that it will be advantageous for the local community to build on existing capacities such as raw material extraction and/or processing.

On the other hand, at the same time food and textile industries as well as service sectors are gaining strength in the Batken province, which provide broader opportunities for alternatives.

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List of acronyms and abbreviations

MAC	Maximum Allowable Concentration
REHRA	Rapid environment and health risk assessment project
SES	Sanitary Epidemiological Station
UNEP	United Nations Environment Programme
UNITAR	United Nations Institute for Training and Research
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USSR	Union of the Soviet Socialist Republics
VCM	Vinyl Chloride Monomer
WB	World Bank
WHO	World Health Organization

Chemical symbols and conversion factors

Hg	Mercury
Sb	Antimony
ha	Hectare (10,000 sq metres)
km	Kilometre (1,000 metres)
ppm	Parts per million, 1 ppm equivalent to 1 mg/kg or 1 mg/l
som	Kyrgyz currency unit: US\$1 is equal to 35 Kyrgyz som

1 Introduction

1.1 Background

After major mercury mines such as in Spain and Algeria closed down in the last 10 years, Kyrgyzstan and its Khaidarkan¹ Mercury Company is now the only remaining major producer and supplier of primary (virgin) mercury for the global market. In the context of global efforts to improve health and environment risks arising from mercury production and use, the international community has recognized that priority should be given to assisting Kyrgyzstan on the issues related to mercury including socially responsible closure of active mines.

While the modality and overall approach for global controls is not clear at this time, one can expect that global supply of mercury will be managed and that accessing existing sources of mercury is likely to become a preferred source of mercury over new primary mined mercury in this interim phase. It is highly likely there will be global controls in place on mercury within a 10 year time frame.

The 'Development of an Action Plan to Address Primary Mercury Mining and its Impact on the Environment in Kyrgyzstan' project is carried out as a partnership between UNITAR, UNEP and UNEP/GRID-Arendal with support from the Government of Switzerland and the United States of America.

One of the project components is the present Technical Assessment of Khaidarkan mining operations carried out by UNEP/GRID-Arendal in cooperation with the Kyrgyz State Agency on Environment and Forestry experts, and other local and international partners. This component is completed by a Socio-economic Assessment of the Khaidarkan area, implemented under the supervision of UNITAR, with the aim to identify the relevance of mercury mining in the area and outline socially responsible approaches for reducing mercury related risks.

In the past UNEP/GRID Arendal has worked on various projects in mining and the environment all over the EECCA regions and South East Europe, as a partner institution in implementation of the Environment and Security Initiative (EnvSec)². Within this framework UNEP/GRID Arendal investigated the Khaidarkan tailings dam through the Rapid environment and health risk assessment (REHRA) project implemented jointly with the Italian Ministry for Land, Territories and Sea and ICARO Ltd in 2005-7. The present project benefits largely from the experience and networks established during the REHRA as well as other projects in the Ferghana valley, Central Asia, as well as expertise in mining related environmental and social issues.

This assessment examines the state of mercury mining at Khaidarkan, investigates the environmental significance and known and potential impacts of primary mercury mining

¹ For the purpose of this report the name of Khaidarkan is universally applied. Other names in use include: Haidarkan, Khaidarken, Aidarken, etc.

² ENVSEC (Environment and Security), a joint initiative between UNEP, UNDP, UNECE, OSCE, NATO and REC-CEE, identifies linkages between major environmental concerns within European sub-regions and countries, and existing or potential security problems that impact on people and states

activities, predominantly at the local level, and identifies the industrial alternatives to mercury production which should support the development of an Action Plan prepared by Kyrgyz authorities to address environmental issues related to primary mercury mining.

This Technical Assessment aims to assist in the work of local and international experts and organizations by analyzing the current situation and trends in the Kyrgyz mercury mining sector, summarizing legal and institutional regulations and programmes that manage and control mercury mining and emissions, reviewing environmental issues and legacies associated with current and historical mercury production, providing a set of recommendations for an action plan and listing alternative development options.

A successful Action Plan addressing environmental and socio-economic issues related to the primary mercury production requires an integrated approach. Ultimately this action plan, which is being developed by Kyrgyzstan's inter-agency workgroup, should identify a set of cost-effective options to move forward with reduction of the Kyrgyz mercury supply to the global market, making the local environment safer and sustaining an acceptable lifestyle for the local community.

National experts indicate that the next steps towards phasing out of mercury production in Kyrgyzstan should be supported by appropriate adjustments in legal regulations and programmes, in order to ensure a consistent approach and policies in industrial scale mercury production and to prevent uncontrollable small-scale mercury mining, which may start at many of the country's smaller deposits to replace industrial Hg mining.

1.2 Structure

The Technical Assessment consists of 8 Chapters and 4 Appendices. Chapter 2 provides an overview of mercury in the global context; Chapter 3 reviews legal, institutional and technical frameworks for the control of mercury in Kyrgyzstan; Chapter 4 discusses the socio-economic and geographic situation of the Khaidarkan Valley; Chapter 5 provides an insight into the history of mine development, geological reserves and technological processes at the Khaidarkan mercury mine; Chapter 6 characterizes pollution sources, potential and known environmental contamination pathways and health risks; Chapter 7 elaborates on development opportunities, mostly industrial alternatives; Chapter 8 provides recommendations for an action plan. Annex 1 analyzes the situation at the abandoned mines. Mercury levels in the environment, international and Kyrgyz values are provided in Annex 2. Additional tables provided in Annex 3. Selected photographs are listed in Annex 4.

1.3 Methodology and assessment approach

Information presented in this report has been gathered in several project stages starting from April 2008. Following three steps comprised the main areas of work:

1. Desk research

2. Meetings and interviews on-site
3. Supplementary sampling and chemical analysis

Kyrgyz institutions and individuals consulted in the assessment process

- 1 State Agency on Environmental Protection and Forestry (K. Noruzbaev)
- 2 Osh Aarhus Center (K. Isabaev)
- 3 Kyrgyz Mining Association (V. Bogdetsky)
- 4 Batken territorial department for environmental protection (A. Temirkulov)
- 5 Osh territorial department for environmental protection (I. Isabaev)
- 6 Department for Mining Inspection and Industrial Safety
- 7 National Statistics Committee (N. Kavanova)
- 8 State Agency on Geology and Mineral Resources
- 9 Institute for small hydropower and renewable energies, Bishkek
- 10 Institute for medical problems, Osh
- 11 Ministry of and Trade and Economic Development
- 12 Academy of Sciences
- 13 Kadamjai sanitary-epidemiological station
- 14 Osh sanitary-epidemiological station
- 15 Khaidarkan hospital
- 16 Southern Kyrgyz Geological Survey in Osh
- 17 Ministry of Emergencies
- 18 Ministry of Fuel Resources and Industry
- 19 Office of the Khaidarkan plant in Bishkek
- 20 Khaidarkan plant
- 21 Town administration of Kyzyl-Kya
- 22 Town administration of Nayman
- 23 Town administration of Khaidarkan

Substantial knowledge on mercury production, economic and environmental impacts and social relevance of the mine has been gathered by projects led by the World Bank, MMSD and UNEP. A review of this material provided an overview of the local relevance of operations and indicated the scale of environmental concerns to be addressed in the project.

Based on the resulting Desk Assessment and identified data gaps, two missions were conducted to obtain relevant documents available in Kyrgyzstan and to launch cooperation between the project and local experts and stakeholders. Interviews, archives, and institutional research yielded more insight on organizational and technical complexities. Of particular importance is the Ecological Passport of Khaidarkan produced in 1990, which provides invaluable environmental data on the peak production period.

Existing data was completed by water, soil and plant sampling which should deliver a screening of environmental pollution through chemical analysis. For quality control and due to the limited capacities of Kyrgyz laboratories, samples were analyzed in Switzerland at the Geneva Cantonal Laboratory as well as at the Alex Stuart Laboratory in Kyrgyzstan.

1.4 Limitations

The most significant limitations on this project were imposed by limited data availability. Firstly, the recent administrative changes in which responsibility for Khaidarkan supervision was transferred from Osh to Batken environmental departments and then back again resulted in inconsistent data series and fragmentation of documentation.

Secondly, there are severe deficits in implementing monitoring requirements as regulated through Kyrgyz environmental law. Documents are not updated or not disclosed, either because they are considered commercial secrets or for other reasons. The mining company is not open in providing full information about its technical, economic and environmental activities to the project experts as well as to the governmental institutions monitoring it.

Many methodologies for data generation on environmental issues are not transparent and ecological and medical information on health impacts is incomplete and often outdated. State laboratories have very limited capacities for analysing key pollutants and no quality management system is in place to ensure reliability.

This report relies on the best available data that has been verified by various local and international experts.

2 Mercury in the global context

Mercury has been used for a vast variety of products but it has gradually been replaced in processes and goods for technical, as well as health and environment related reasons. Where mercury applications persist, it is often due to a lack of financial resources to improve outdated technologies, inadequate legal provisions or lack of enforcement and control.

Examples of mercury use:

- Chlor-alkali industry which uses mercury as a catalyst in the production of chemicals.
- Production of vinyl-chlor-monomer, a synthetic material, also using mercury as a catalyst to make PVC.
- Artisanal small-scale gold mining which uses mercury to extract gold from the ore.

For the first two, viable mercury-free alternatives exist and are largely being applied with a few exemptions. Artisanal small-scale gold mining on the other hand seems to remain a big concern because of the difficulties managing its application and the resulting impacts. During the gold extraction process, mercury is used to form an amalgam with gold to separate it from remaining ore. Once the amalgam has formed and is separated, pure gold is obtained by heating the amalgam until the mercury evaporates. Large amounts of mercury are thereby released into the environment where it becomes a global pollutant.

Artisanal and small-scale gold mining (supplying up to 30 per cent of the world's gold) remains the largest global user of mercury and is the largest source of releases, in addition to raising serious concerns regarding global poverty and health.

2.1 Supply of primary mercury to the world market

Even though mercury may routinely be traded several times before final “consumption”, the statistics suggest that global annual trade in mercury and its compounds amounts to an estimated US\$100 million to US\$150 million

The main economically viable sources of mercury for supply to the world market are geological deposits of the mineral cinnabar which is mercury sulphide (HgS). Compared to primary mercury which is derived from mercury ore such as cinnabar, secondary mercury is recovered by refining base metal and waste reprocessing. At a global level, basic mercury reserves exceed 280 000 metric tonnes (with potential reserves in excess of 600 000 tonnes), mostly in Spain (over 90 000 tonnes), Italy (over 70 000 tonnes), Kyrgyzstan (over 40 000 tonnes), China, Algeria, Slovenia, Russia and Ukraine.

After centuries of manual mining and the technology-driven methods of the last century, substantial primary mercury mine closure took place during the 1990s in Italy, Mexico, Peru, Slovakia, Slovenia and Turkey. Most recently, mercury mines in Spain and Algeria shut

down primary mercury mining activities in 2004 due to economic difficulties caused by low commodity prices and environmental concerns. Today, Kyrgyzstan and China are the only remaining countries which produce primary mercury on an industrial scale whereby the Khaidarkan mine in Kyrgyzstan is the only site from which mercury is exported to the global market. Kyrgyzstan's current annual mercury production amounts to 300 tonnes a year. China, which is also a main consumer of mercury, has restricted mercury imports to less than 300 tonnes a year and reportedly focused on domestic production of primary mercury, particularly in the Guizhou province. The USGS Mineral Commodity Summary (2008) estimates China's mercury mining output at 1 100 tonnes a year³.

After the closure of major mercury mines in Spain and Algeria, the supply to the world market dropped, with a simultaneous rise in mercury prices which rose from US\$170 for one flask (34.5 kg) in 2001 to US\$550 in 2007. The price reached its peak in 2005 when prices jumped to US\$775 a flask (USGS 2008). As a result of this price increase, global mercury consumption in products decreased, while a variety of non-mining sources of mercury scrambled to meet demand. Once a new supply-demand equilibrium was achieved, the price of mercury eased, although it remained higher than its pre-2003 level (UNEP 2008).

As a result of the volatility surrounding these market adjustments, a larger variety and larger quantities of mercury waste are now treated for recovery than previously, more by-products containing mercury are separated from the waste stream, more mercury is generated as a by-product, and more mercury is now held in storage to deal with future supply disruptions. In other words, the global supply of mercury has become more diverse, while the high price of mercury (not to mention increasing awareness of environment and health concerns) continues to put pressure on mercury users to further reduce consumption and shift to viable mercury-free alternatives (UNEP 2008).

The contributions of Kyrgyzstan to the global mercury supply over many years have been important but not indispensable. The recent experience in closing both Spanish and Algerian mining operations, which represented a larger part of the global mercury supply than does Kyrgyzstan's mines, have demonstrated that mercury demand can readily be met without primary mercury from Kyrgyzstan (UNEP 2008).

2.2 Mercury in the environment

Anthropogenic mercury releases into the biosphere result from industrial or small-scale air emissions and deposition of waste products in waterways, soils, oceans from where they enter the food chain. Globally, most anthropogenic mercury releases originate in non-primary anthropogenic sources, e.g. fossil fuel combustion (especially coal-fired plants and household sources), cement and gold production. For comparison, officially reported mercury emissions into the atmosphere from the Khaidarkan mine amount to 2.7 tonnes a year which represents less than 0.2 per cent of global mercury emissions (roughly 2 000

³ In the same report mercury production by Kyrgyzstan is estimated at 250 tonnes in 2006 and 2007

tonnes a year in 2005-7). However, actual emissions from Khaidarkan could be as high as 16 to 20 tonnes a year at full capacity, as stated in the Khaidarkan ecol. passport (1990).

Mercury, once released into the biosphere, can travel for a long time and over long distances. It accumulates in organisms and the higher an organism is in the food chain, the more mercury accumulates in its body. Humans are often at the top of food chains. Therefore, mercury is a global pollutant which has an impact far beyond its point of origin as can be seen in the high mercury levels in biota in the Arctic Sea which are not exposed to mercury emissions in their immediate surroundings but show significant levels of mercury in their tissue.

2.3 Mercury effects on human health and the environment

Mercury can be found in various chemical states and compounds which is also reflected by varying toxicity. Most alarming are organic mercury compounds formed from inorganic mercury by microbes that are able to build up organic structures that contain mercury, for example in the bottom of a waterway. Methylmercury is a commonly found organic mercury compound and therefore it is often used to refer to the entire group of organic mercury compounds. When organisms consume methylmercury, in particular fish, the toxin accumulates in the body, in particular in the fatty tissue, whereby it becomes available to other organisms, e.g. to humans. Methylmercury effects on humans are particularly severe for foetuses and children. Primary health effects of methylmercury are impaired neurological development. It can adversely affect a baby's growing brain and nervous system. Impacts on cognitive thinking, memory, attention, language, and fine motor and visual spatial skills have been seen in children exposed to methylmercury in the womb. In addition, symptoms of methylmercury poisoning may include lack of coordination of movements, impairment of speech, hearing, walking and muscle weakness. Methylmercury exposure in adults has also been linked to increased risk of cardiovascular disease.

Exposure of inorganic mercury is less severe but still has very serious negative effects on human health. Neurological and behavioural disorders in humans have been observed following inhalation of elemental mercury vapour, ingestion or dermal application of inorganic mercury-containing medicinal products and ingestion of contaminated food. Specific neurotoxic symptoms include tremors, emotional liability, insomnia, memory loss, neuromuscular changes, headaches, polyneuropathy, and performance deficits in tests of cognitive and motor function.

2.4 UNEP Global Mercury Partnership

UNEP Governing Council concluded at its 22nd Session in 2003 that there is sufficient evidence of significant global adverse impacts from mercury and its compounds to warrant further international action to reduce the risks to human health and the environment. At that

time, the UNEP Governing Council decided that national, regional and global actions, both immediate and long-term, should be initiated as soon as possible.

In response to this, UNEP established a mercury programme within UNEP Chemicals in 2003. At this time, the two major areas of work for the mercury programme comprise the UNEP Global Mercury Partnership that facilitates coordinated near term actions on mercury and the establishment of an ad hoc open-ended working group of Governments, regional economic integration organizations and stakeholder representatives to review and assess options for enhanced voluntary measures and new or existing international legal instruments.

In order to effectively reduce the quantities of mercury circulating in the atmosphere and biosphere, it is widely agreed that there is a need to reduce simultaneously both the supply of, and demand for, mercury worldwide. Although there is no formal partnership on mercury supply, the international community has recognized that near term priority should be given to assisting Kyrgyzstan address environmental and health risks related to primary mercury mining, and socially responsible closure of active mines through the UNEP Global Mercury Partnership. In addition, the mercury ad hoc open-ended working group has developed a comprehensive policy framework to address mercury globally that identifies the reduction of mercury supply as an area for specific action and includes consideration of phasing out existing primary mining, taking into account the circumstances of countries.

While the modality and overall approach for implementing the comprehensive mercury policy framework is not clear at this time, one can expect that there will be global controls in place on mercury within a 10 year time frame which will severely restrict the long term viability of mercury mining and that accessing existing sources of mercury is likely to become a preferred source of mercury over new primary mined mercury while mercury is phased out.

3 Kyrgyz environmental protection frameworks related to mercury mining and emissions

3.1 Legislation

The legislation of Kyrgyzstan is relatively extensive and comprehensive when it comes to regulating the mining sector and environmental protection. This chapter provides an insight into some aspects of relevant legislation and programmes with an overview of the content and shortcomings relevant to mercury mining, environmental pollution and remediation of mined out sites.

The initial Law of the Kyrgyz Republic on subsoil use (1992) released shortly after the country's independence was silent on the responsibility of the operators to make provisions for orderly closure and rehabilitation of mined out areas. This deficiency was partially remedied in the 1997 and 1999 revisions of the Law on subsoil use, which included some provisions obligating the mining operator to close the mine in an orderly manner. However there are no specific regulations indicating the exact responsibilities of the operator and the state bodies with respect to mine closure.

The Law of the Kyrgyz Republic on the bowels of the earth (1997) requires to limit environmental pollution of earth embowels, including disposal of waste and discharge of wastewater.

The Law of the Kyrgyz Republic on licensing (2001) plays an important role in permitting the utilisation of mineral resources, including mercury reserves. It also regulates disposal and elimination of the toxic waste, (cross-border) transportation of toxic waste and substances.

It is noted in the Country Development Strategy 2009 that regulations, instructions, and orders in the mining sector of Kyrgyzstan widely interpret laws complicating the licensing procedures and miners' activities.

A number of legal acts and requirements on the environment and industrial safety are available in Kyrgyzstan, of which the following are most relevant in the context of mercury and other toxic chemicals:

- The framework Law of the Kyrgyz Republic on environmental protection (1999) defines the policy and role of the state and other actors and regulates the legal aspects of environmental protection;
- The Law of the Kyrgyz Republic on air protection (1997) provides a framework for preventing and minimizing air pollution, and controlling emissions;
- The Law of the Kyrgyz Republic on environmental assessment (1999) provides the basis for environmental impact assessments and expertise;

- The Law of the Kyrgyz Republic on Industrial safety of hazardous production facilities defines the legal, economic and social framework securing safe operation of hazardous industrial facilities;
- The Law of the Kyrgyz Republic on tailing ponds and mining heaps (2001) aims to secure the environmental and operational safety and proper management of tailings ponds and mining heaps;
- The Law of the Kyrgyz Republic on waste from the production and consumption (2001) defines state policy in waste handling, prevention of negative impacts on the environment and human health, promotion of reprocessing and reuse of waste materials;
- The Law of the Kyrgyz Republic on rate of payment for environmental pollution (emissions, discharge of polluting substances and waste disposal) (2002) introduces charge of 1.2 som for one tonne of pollution equivalent.
- The Law of the Kyrgyz Republic on industrial safety of hazardous production facilities (2001) defines legal, economic and social aspects of safe operation of the hazardous facilities, preparedness and response to the consequences of industrial accidents
- The Law The Law of the Kyrgyz Republic on water (1994) defines the relationships in use and protection of water resources, prevention of environmentally harmful effects of economic activities;
- The Water Code of the Kyrgyz Republic (2005) regulates relations on water use and protection of water resources to ensure sufficient and safe supply of water to the population;
- The Land Code of the Kyrgyz Republic (1999) regulates relations on land use and protection of land resources and soils. The code obliges land users to rehabilitate lands/soils and fulfil the requirements on nature protection:
- The Law of the Kyrgyz Republic on sanitary-epidemiological welfare of the population (2001) aims to ensure appropriate epidemiological conditions for the safe living and reinforce implementation of the constitutional rights of citizens to health and a favourable environment;
- The Law of the Kyrgyz Republic on the protection of public health (1992) stresses that environmental conditions should not pose risks and jeopardize the public health

International conventions and other agreements:

- The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (ratified by Kyrgyzstan in 1995);
- The Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (ratified Kyrgyzstan in 2000)

- The UNECE (Aarhus) Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (adopted in 2000). The Osh Aarhus centre, supported by OSCE is largely involved in public awareness activities, including in Batken province;
- The UNECE Convention on Long-range Transboundary Air Pollution (adopted in 2001). Kyrgyzstan has already submitted its national report on air emissions for 1990-2000 to the Convention Secretariat;
- The UNECE (Espoo) Convention on Environmental Impact Assessment in a Transboundary Context (adopted in 2001). Kyrgyzstan and Kazakhstan are taking part in the pilot project on gold mining in cross-border area.
- The UNECE Convention on the Transboundary Effects of Industrial Accidents (adopted in 2001). Kyrgyzstan participates in the partnership and capacity building programme on implementation of the basic provisions of the Convention;

3.2 Environmental monitoring and compliance instruments

In general it appears that many official requirements for monitoring and restricting air emissions and flow discharges for mercury (and other toxic substances) largely follow the limits set and applied during the Soviet era, when the State Hydrometeorological Service of the USSR was responsible for carrying out related activities. For the last 15 years, compliance with governmental regulations regarding mercury emissions has been monitored by the State Agency for Environmental Protection and Forestry and its predecessors, such as the Ministry of Emergencies and Ecology, etc.

The Khaidarkan plant is required by law to prepare an Ecological Passport, which contains the inventory and agreed limits for emissions into the environment (Maximum Allowable Emission (MAE) for airborne pollutants and Maximum Allowable Discharge (MAD) of effluents into water), as well as an action plan with environmental protection measures to which the plant is committed (eg re-vegetation, cleaning of filters, waste processing, etc.). The MAE and MAD levels as well as target values calculated and approved by the State agency on environment and forestry. The problem with the MAE and MAD approach is that it does not necessarily address the impacts of discharges and emissions on ambient conditions. MAE and MAD methods focus on the discharge rather than the effect in the receiving environment. This approach is not consistent with the international approach to minimize pollutants as far as possible.

The passport needs to be prepared by the operator and has to be renewed every five years. The Khaidarkan plant currently has an environmental action plan but the main Ecological Passport dates back to 2000 (a copy of recent passport was not made available to the project experts by the central/local environmental authorities nor the plant management, which questions the fact of passport availability). Reportedly, the process for renewing the document is underway. The previous passport was issued in the Soviet period (1990), the

period of peak production levels and reportedly strongest environmental impact. Therefore it also serves as a useful reference basis for this assessment.

Although the Ecological Passport considers pollutants emissions, discharges and resource use (ore extraction, land take, water consumption, energy use, etc) this approach is non-dynamic and can result in environmental problems going un-noticed. The current international best practice views environmental management as an on-going process throughout the lifetime of the mine and smelter from construction to operation to final decommissioning and clean-up.

Khaidarkan does not publicly report on its environmental performance. In spite of public concerns over environmental situation and potential risks from the hazardous waste virtually no data on emission of pollutants and waste, pollutant concentrations and hazardous areas is available to the public, nor are any independent audits.

To comply with environmental regulations and reduce environmental pollution, a number of technical measures are annually planned by the Khaidarkan plant. These measures include: cleaning of wastewater canals and pipelines, processing of sludge waste, cleaning up of industrial sites and occupational clothes to remove mercury contamination, purification of air filters, maintenance work on the tailing pond, green plantations, etc. The annual cost of environmental protection measures implemented by the plant is estimated at 500 000 soms (in 2008). Past experience shows regular non-compliance with environmental regulations, sometimes by significant amounts (MAC values exceeded by a factor of 10-100). It appears likely that mercury emissions as reported by the industry disagree with the actual emissions. This however cannot be verified by instrumental data (see section 6.2.1. for discussion).

Taxes (fixed charges) are payable annually by the Khaidarkan plant for the use of natural resources and for discharges within the approved MAE and MAD limits. Fines are levied if emissions or discharges exceed the approved limits. At the Khaidarkan plant, as in many other mining enterprises of Kyrgyzstan, the MAE and MAD levels are calculated rather than physically measured. Fines are transferred to special accounts with off-budget state funds and used to finance activities aimed at environmental protection and sanitation.

3.3 Policies

At a strategic level, the National Environmental Action Plan NEAP (1995) of the Kyrgyz Republic appropriately describes environmental issues in the mining sector and calls upon for action by state actors, donors and business to remediate the legacies of the past and improve current mining practices. The NEAP critically assessed conditions at the abandoned and active mercury mines and requires response measures. However, for lack of funding, many measures and recommendations have not been implemented. The National Environmental Health Action Plan NEHAP (1999) supplements NEAP with activities on the protection of human health from environmental risks and threats. The National Environmental Security Concept of the Kyrgyz Republic (2007) considers the environmental

aspect of mining operations, although it does not include any specific provisions related to mercury mining.

The Country Development Strategy (2009) of the Kyrgyz Republic for 2009-2011 primarily focuses on the following types of extractive industries: gold mining, construction materials (cement), energy resources (coal, oil, gas) and does not mention mercury production among priorities. The Strategy indicates that there are four industrial mercury reserves: two reserves are not in use (abandoned-dormant mines, see Annex 1 for details), and the remaining two with 16 400 tonnes of metal are used by the Khaidarkan plant, which is experiencing economic difficulties due to fluctuations of mercury prices and low profitability.

Other state programmes such as the Programme (2002) for industrial development of the Kyrgyz Republic for 2002-2004 (until 2010) and the Programme (2007) on export development and import substitution of the Kyrgyz Republic for 2007-2010 consider continuation of Khaidarkan's operation with mercury output at 350 t/y, which is not consistent with the provisions of the Country Development Strategy 2009. In this situation it would be essential to re-define future priorities (beyond 2010) for Kyrgyzstan's mercury production, taking into account international environmental requirements and gloomy prospects of global mercury market.

3.4 Responsibilities

Internationally, governments which have owned the state mining enterprise usually take responsibility for the legacy of pollution stocks, mainly because they have derived most of the benefits during the operational period prior to take over. The situation of the Khaidarkan is complex with the USSR as the only consumer for its final products (Khaidarkan produced up to 80 per cent of USSR's mercury), whereby Kyrgyzstan benefited from social services.

According to the Law on environmental protection, residual pollution or damage to the environment caused before 1992 is considered the responsibility of the state. Adequately identifying and attributing environmental liabilities is important for the previous owner (the state) and the new private owner. In the unlikely scenario of Khaidarkan privatization (see section on privatization attempts) experts believe that responsibility for environmental legacies, especially land contamination and waste, will most likely be assigned to the Ministry of emergencies and local administration.

If conditions for privatization involve major obligations for the private owner to address environmental pollution, it is expected that assets will become highly unattractive. Therefore a potential private owner will require that the stocks and flows of the pollutants be defined by an audit and agreed with the government. In the discontinuation of mercury production scenario due to economic hardship or other reasons, plant management should take responsibility for the clean-up. It should be noted that objects requiring remediation and clean-up are supposed to be specified in the Ecological Passport, which is not available.

It appears that the Khaidarkan plant does not set aside any funds for the purpose of environmental clean-up, rehabilitation of mined out areas, and protection of community

benefits. Therefore financial guarantees for environmental rehabilitation are very uncertain, and it is likely that the local community and administration will face all the burden of environmental pollution that is left around production site.

The case studies of the two abandoned mercury mining sites of Kyrgyzstan in Ulug-Too and Chauvay (described in Annex 1), which stopped operations in the early 1990s, show that no remediation or safeguarding activities were carried out. This clearly indicates that both environmental and mining legislation are deficient and not fulfilled due to weak capacities of the state control authorities and limited budget. Until recently the Ministry of Emergencies, which is responsible for radioactive safety and elimination of major pollution risks (incl. tailings), is not assigned with responsibilities for monitoring, control, and rehabilitation of the two above mentioned abandoned mercury mines.

3.5 Institutions involved in mercury mining issues and environmental protection

Previously, the Khaidarkan plant used to be supervised and controlled directly by the Ministry of Industry. Now, Khaidarkan has autonomy in management, arranging contracts, accounting, etc. The Ministry of Industry, Energy and Fuel Resources mainly fulfils a planning, coordination and information gathering function. The State Property Committee holds the 99.9 per cent government share holdings in Khaidarkan. The State Customs Committee makes the Khaidarkan plant eligible for simplified customs procedures on import-export.

Several state institutions are involved in managing mercury mining issues in Kyrgyzstan. Key institutions include: the Ministry of Industry, Energy and Fuel Resources, the State Agency on Environmental Protection and Forestry and its territorial departments, , the State Agency on Geology and Minerals, the Ministry of Emergencies, the Committee on State Property. Among other actors, NGOs such the Osh Aarhus centre, research institutes (Institute of the medical problems, Sanitary-epidemiological services of Kadamjai and Batken) and laboratories (Alex Stuart lab, Chui Ecological Lab, Osh Lab) are relevant to the project.

The State Agency on Environmental Protection and Forestry of the Kyrgyz Republic (SAEPF) is a specially designated governmental institution dealing with inspections, issue of permits and limits for emission release into the environment, review of environmental protection plans, EIA, and various environmental monitoring activities. SAEPF has been appointed as the lead agency for coordinating this mercury project and preparation of Action Plan in Kyrgyzstan⁴. However, as the latest UNECE Environmental Performance Review for Kyrgyzstan (2009) indicates, the low status of the State Agency in the Government and decision-making structure creates difficulties when it comes to defending ecological interests and raising environmental priorities.

⁴ The Kyrgyz Government decree on the establishment of the inter-agency workgroup on mercury action plan (10 March 2009)

The Osh-Batken inter-territorial department for environmental protection reports to the State Agency on Environmental Protection and Forestry and is involved in supervising local environmental issues. From the economic viewpoint Osh province is mostly agrarian, whereas the main industries (mercury, antimony, coal) are operating in Batken province. This report consequently focuses on issues specific to Batken.

The Batken territorial department for environmental protection carries out quarterly inspections and implements an analytical survey of the Khaidarkan mining plant once a year in cooperation with the Kadamjai sanitary-epidemiological service (SES). The plant reports quarterly on its environmental situation, emissions and waste formation to the Batken territorial department. When emissions limits are exceeded, fines are imposed on the mine based on each case. Apart from these fines, the mine contributes financially to a Nature Protection Fund of the Batken territorial department. Contributions are based on the extent to which the mine exploits natural resources and ecosystem services and should compensate for the negative impact of operations. Khaidarkan's annual contribution to this fund amounts to about 300 000 som (approx. US\$7 500). Almost three-quarters of these payments remain in the local budget. The advantage of retaining the funds at province level is that it affords the opportunity to re-invest them in locally beneficial environmental projects.

The Central Statistical Office of the Kyrgyz Republic collects information about pollution levels (air emissions, wastewater discharge, water use, waste accumulation) directly from the relevant industrial activities, including Khaidarkan, and publishes summarized information in its state of the environment reports (statistical format) every three to four years. Data on imports and exports of industrial products is also available from the statistical office and customs service. It should be mentioned, however, that mercury production data, including export destinations and financial performance is not publically available.

The State Agency on Geology and Minerals is tasked with: estimating and keeping a balance of mineral resources and reserves; carrying out feasibility studies; monitoring the use and protection of subsoil by industry; developing and approving a legal basis for geological investigation and protection of deposits; imposing sanctions for excessive loss of minerals during their extraction and processing. It plays a major role in issuing licenses, including for mercury production.

The State Inspection on Industrial and Mining Safety under the Ministry of Emergencies carries out state regulation on safety in mining, geological prospecting and other drilling work, the exploitation of tailings dams, shafts and also the storage, stock-taking and use of industrial explosives. The Inspection issues licenses covering the technological aspects of construction and exploitation of mining and metallurgy facilities and geological prospecting, and supervises measures for the prevention and elimination of the negative impacts of mining operations on health and the environment. Another unit in the Ministry of Emergencies deals with the safety of the abandoned and active tailings ponds (abandoned mercury production sites and waste are not included). The Hydrometeorological service under the Ministry of Emergencies carries out a nationwide environmental monitoring programme, focusing on urban air quality and radioactive fallout. Apparently this programme does not cover mercury monitoring at Khaidarkan.

The independent laboratories specializing in environmental analysis (detection of heavy metals, services for mining industries) are the Alex Stuart Environmental Laboratory and the Chui Ecological Laboratory in Kara-Balta (70 km from Bishkek). The past 10 years experience shows that private laboratories appear to be more professional and internationally certified, better equipped and able to sustain activities due to broad range of services, clients and commercial possibilities. In contrast, many state-run laboratories have serious lack of funding (even if equipment was granted) and experts (brain drain of professionals to the private sector), arguably poorer quality of services and narrower specialisation and list of clients. This situation makes state-run environmental monitoring a challenging task, especially in the case of heavy metal (mercury, lead) pollution monitoring.

The Khaidarkan Mercury Plant and Osh Environmental Administration also have laboratories dealing with pollutants, although their equipment and methodology are considered out-of-date. Sanitary-epidemiological station in Kadamjai which is tasked with monitoring of environmental health conditions at Khaidarkan has an operational mercury air-sampling equipment and spectrometer. However, SES measurements are rare and limited in scope. Technical assistance for enhancing environmental monitoring capacity has already been provided by international donors (such as ADB, GEF) and is seen by the national and local environmental authorities as the main component in efficient environmental control and enforcement.

4 Khaidarkan valley

4.1 Population

The Khaidarkan mercury mine is located in the south of the Kyrgyz Republic, a landlocked country in Central Asia covering 199 900 sq km, bordering China, Kazakhstan, Uzbekistan and Tajikistan. It is subject to the Kadamjai district of the Batken province (16 995 sq km) in south-west Kyrgyzstan. There are four towns, five urban settlements, and over 180 villages in the province, which is home to about 423 000 people. A quarter of the population is living in towns, the rest in the countryside, mainly from farming. The population density of Batken province is 23 people per sq km.

Figure 1 Kyrgyzstan map



In 1989 the total population of Khaidarkan was 11 500 people of which 3 500 were employed by the enterprise. Since independence, the number of industrial workers has dropped to 1500 employees in the middle/late 1990s, to 750 employees in 2008, while the population of Khaidarkan has fallen to 9-10 thousand (in 2007-8). The mine is still a vital source of income for local people. A community of 15 000 to 20 000 people located in Khaidarkan and neighbouring villages of Eshme, Sur and Bel are strongly linked to the mercury mining operations. Livelihoods in these communities are largely dependent on the enterprise, through direct and indirect employment as well as through the provision of services, e.g. water for irrigation. The main crops grown in the area are potatoes, carrots and cereals.

Currently Batken province contributes 3-4 per cent of national GDP and generates 2 per cent of country's industrial produce and 9 per cent of agricultural produce. Batken's industrial production in 2008 amounted to 1 500 million som, agricultural production 7 500 million som. Capital investments totalled 2 200 million som, half of which is associated with the construction of the cement plant at Kyzyl-Kya. The average salary in Batken province in 2008 was 3 820 som⁵; at the Khaidarkan plant about 5000 som.

4.2 Mineral mining

The 20th century saw intense development of the mining industry in Kyrgyzstan. The country's mining sector played a substantial role in the raw material economy of the USSR supplying at some points 15-18 per cent of lead, 40-100 per cent of mercury (mostly from Khaidarkan), 100 per cent of antimony (Kadamjai), 30 per cent of rare-earth metals and 15 per cent of uranium production. At present the mining industry, especially gold production, is a core industry in the Kyrgyz Republic. Its output by 2004 increased to 25 500 million som. Gold mining generates over 40 per cent of the export income, most of which is produced by the Kumtor gold mine (17.3 tonnes of gold in 2008). Khaidarkan contributes less than 1 per cent of country's industrial produce and export income, and its economic contribution is not significant compared gold mining.

Batken province has several, abundant mineral deposits that could form the basis for substantial industrial development. The province has great potential for mercury and antimony, coal extraction and to a lesser extent for gold, oil, gas and construction materials. National stamps feature the rich and diverse geological features of Southern Kyrgyzstan, especially Khaidarkan.

Figure 2 Kyrgyzstan national stamps featuring minerals from Khaidarkan



Oil and gas reserves are limited to 13 million tonnes of oil and 3.5 million cu m of gas, mainly located in the north-western part of Batken province, in the foothills of the Ferghana valley. On average 18 000 to 20 000 tonnes of oil are produced annually (25 per cent of national production). The coal deposits of Sulukta, Kyzyl-Kya and smaller sites amount to 355 million tonnes. Current production levels are 60-100 thousand tonnes a year (25-30 per cent of national production). Non-metallic minerals include marble, limestone, clay, shale, mica, gravel.

⁵ US\$1 = 40 Kyrgyz som (average in 2008)

4.3 Climate and geography

The Khaidarkan mine is located in the Khaidarkan Valley (elevations 1 700 to 2 000 metres) sandwiched between the Turkestan-Alai mountains in the south and Ishme mountains in the north. The average height of these mountains is 3 000 to 4 000 metres, with peaks higher than 5 000 metres. The Sokh river valley lies to the east of Khaidarkan.

The continental climate of Khaidarkan is dry with an average annual temperature of +6°C. Temperature extremes range from -28°C in winter to +30°C in summer. Frost-free period lasts for 250 days. Annual precipitation varies 350-600 mm, on average 415 mm. Maximum rainfall is in April-May. The shape of the valley inevitably affects local and regional air circulation and rainfall distribution. The prevailing wind blows from east to west with daily and seasonal changes with an average speed of 2.5 m/sec.

Table 1 Climate of Khaidarkan

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average monthly temperatures (°C)	-6.8	-5.1	0.3	7	12.2	15.8	18.5	18	13.3	6.6	0.8	-3.2
Average monthly precipitation (mm)	31	47	70	81	89	64	30	12	7	40	54	31

Source: Hydrometeorological data of Kyrgyzstan

The rivers of Batken province, including the Khaidarkan area, mostly drain into the Ferghana valley. Glacier melt as well as groundwater springs and rainfall are the main sources supplying local rivers such as the Sokh, Isfaramsay, Shahimardan and Gauyan. The cross-border Sokh river, with average annual discharge of 42 cu m/sec and peak flow 200 cu m/sec, originates in the high altitude areas of Kyrgyzstan, passing through Uzbekistan's Sokh enclave, then re-entering Kyrgyzstan and ending in the Ferghana valley. On its way, the Sokh takes water from the Gauyan river that runs through the valley where Khaidarkan is located. Long-term hydrometric measurements on the Sokh river indicate increasing trends of annual flow due to climate warming at the high elevations and glacial melt. The Gauyan is a small but important river, because it supplies water to the Khaidarkan settlement, nearby irrigated land and the mercury industry. There are no long-term records for Gauyan flow.

4.4 Natural hazards

Batken province faces a number of threats from natural hazards that frequently occur in the area. The proportion of reoccurring events is floods 70%, landslides 10 per cent, GLOFS and earthquakes 10 per cent, others 10 per cent. According to the Ministry of emergencies Department of monitoring and forecasting the map of seismic hazard shows Khaidarkan valley in 2nd category of seismic risk. The eastern part of the Khaidarkan settlement is exposed to risks from landslides.

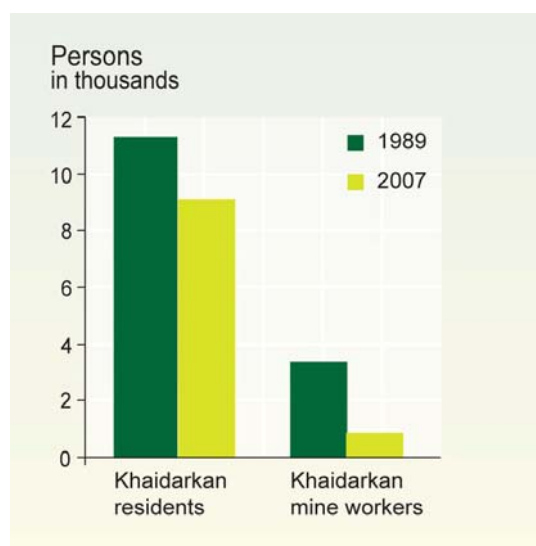
Among the most recent earthquakes were tremors of magnitude M4 to M6.6 in January 2007, June and October 2008 when about 50 people were killed. Their epicentres were

located on the border between Kyrgyzstan and Tajikistan, 200 km east from the Khaidarkan mercury mine. According to the plant, earthquakes are not a hazard for waste sites and industrial infrastructure. A bridge in the village of Orozbekovo (Okhna) on the way to Khaidarkan (30 km east) was destroyed in May 2008 due to flash floods caused by heavy rainfall. A similar natural disaster in 2001 cut the supply of electricity supply to Khaidarkan for several hours and flooded essential parts of the mine.

5 Mercury mining in Khaidarkan

In 2006, the poverty rate⁶ in Batken province was estimated around 50 per cent, being one of the poorest regions in Kyrgyzstan. As in many parts of Central Asia, many young people from Bakten province, including Khaidarkan Valley, work as migrant labourers in Kazakhstan and Russia and send remittances to support the families. However, the economic crisis that recently hit these countries has reduced foreign labour opportunities. Khaidarkan valley residents and services are considered economically and socially dependent on the mercury industry.

Figure 3 Khaidarkan population and mine employment



The history and expertise in mineral extraction as well as the economic hardship experienced in the region over the past decades create firm support for the mercury mining operations among inhabitants, local and national government representatives and authorities.

Currently, the structure of Haidarkan includes the following facilities:

- 1) Management (Administration);
- 2) Two underground works;
- 3) Processing plant, including the tailing;
- 4) Metallurgical plant, including the storage of industrial wastewater with a capacity of 132 thousand m³;
- 5) Laboratory (Department of Technical Control and Chemical Laboratory)
- 6) Electromechanical shop;
- 7) The motor shop;
- 8) Manufacturing unit;
- 9) Security service

⁶ Population with income below subsistence minimum

5.1 Mercury production

1.1.1 History of Development

Metals such as mercury, antimony, uranium and molybdenum, have been traditionally produced in Kyrgyzstan. Of these metals only mercury has a long-term raw material base, but with poor quality ore and complex mining conditions (MMSD 2001). Kyrgyzstan has one of the largest mercury reserves in the world only second after Spain and it became the world's top mercury producer when the Almaden mine in Spain closed in 2004.

Figure 4 Mercury mining sites associated to Khaidarkan



Mercury mining is a long-standing tradition in Kyrgyzstan, where Khaidarkan (which means 'The Great Mine') has always been the main source of mercury in the region.

Industrial-scale mining operations under Soviet management started during the Second World War when technical equipment was shipped to Kyrgyzstan from the Ukrainian Nikitovka mercury mine. At the time mercury was largely consumed by military industry to produce explosive mercury fulminate widely used in primers for rifle and pistol ammunition.

Over the next decades, Khaidarkan grew from a small village into a town of 11.5 thousand people, which benefited from this development through centralised supply of food, medical and social services and good urban maintenance. Mercury productions peaked in the late 1980s with an output of about 800 tonnes a year, representing a quarter of global output at

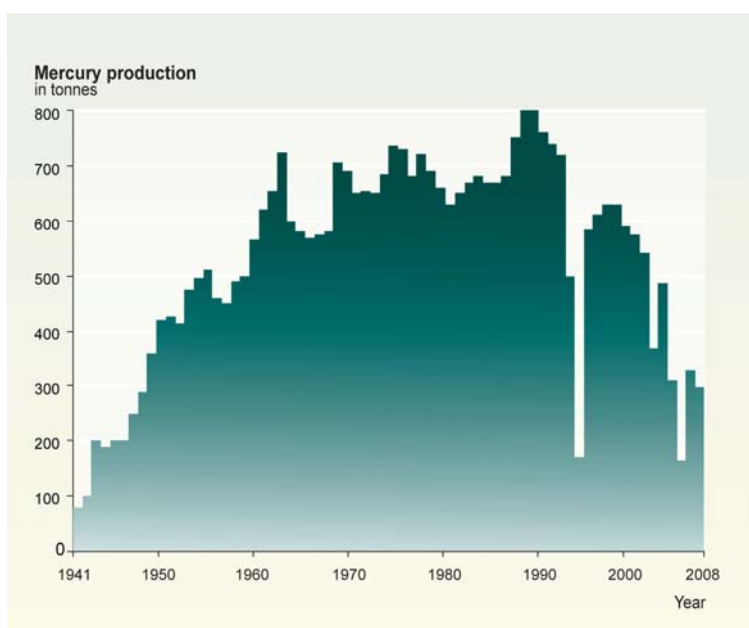
the time⁷. Because of the low metal content and difficult mining conditions the plant operated under the state subsidiary for a long time.

After the collapse of the USSR, the Khaidarkan Mercury Plant lost its mercury outlets and access to cheap energy. Mercury production fell to 200 tonnes and the plant was declared bankrupt. In 1993-94, world price for mercury dropped to \$US 110, while production cost in Khaidarkan at that time was \$US 300. Under the patronage of the World Bank-backed Privatisation and Enterprise Sector Adjustment Credit (PESAC) the plant once again became competitive, increasing output to 600 tonnes a year. By 1997 the workforce had been halved to reduce costs, down to 1,200. World Bank funds were generally intended to convert previously state-owned industries to private ownership which has not been accomplished.

In 2001, a pumping failure at Khaidarkan caused a forcible reduction in mining activities resulting in economic losses which continued into 2006. Although the Kyrgyz government seriously considered shutting down the operations at the time, the mine recovered. Despite ongoing technical challenges at Khaidarkan, in particular difficult mining conditions due to the high water level in the mine, significant energy consumption for water pumps and obsolete technology, Kyrgyzstan continues to produce mercury

Today, the mine reports to operate without state subsidies at an annual mercury output of around 300 tonnes a year (in 2005-2008). Overall, it is estimated that from 1941 until today, Kyrgyzstan mercury production has cumulated up to 45 000 tonnes, of which the Khaidarkan mine alone produced more than 36 000 tonnes. Mercury production in 2008 fell by 20 per cent on 2007 due to deteriorating ore grades, technical difficulties and lack of secondary mercury feedstock.

Figure 5 Khaidarkan mercury production from 1941 to 2008



⁷ Including input from two other mines of Chauvay and Ulug-Too, which contributed roughly 20% of the total output

Other mining products in Khaidarkan comprise fluorspar concentrate and antimony concentrate at annual levels of around 1000 t/a and 100 t/a respectively.

5.1.1 Supply of raw material and energy

Mercury deposits

There are four mercury deposits that have been exploited by the Khaidarkan mining enterprise over the past decades of which only Khaidarkan is still in use today. The figures presented in Table 2 refer to the potentially exploitable reserves at these sites⁸. However, accessibility of these reserves is limited and it requires substantial investment in order to make them fully available to the mining operations. There are numerous smaller reserves of mercuric ores that could be found in south Kyrgyzstan and potentially exploitable by small-scale miners (see map).

Table 2 Industrial mercury deposits of Kyrgyzstan

Deposit	Ore [t]	Mercury [t]
Khaidarkan	7 287 000	10 844
Novoye	2 464 000	5 346
Chauvay	313 000	875
Chonkoy (Ulug-Too)	8 265 000	22 684

Source: Kyrgyz state geological balance (2008)

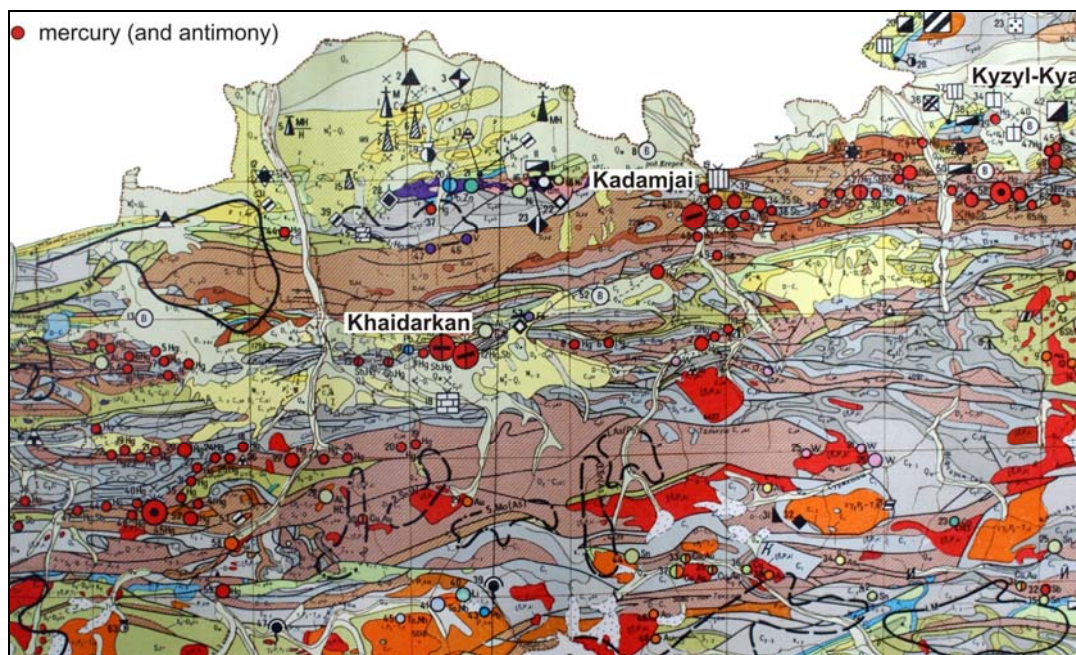
Reserves available to Khaidarkan (including nearby Novoye deposit)⁹ as indicated in the Kyrgyz state balance of minerals for 2008 are 16 500 tonnes mercury, 108 000 tonnes antimony, 1 million tonnes fluorspar.

Chonkoy and Chauvay deposits are located about 100-120 km east of Khaidarkan (by road) and in the past they had their own mercury mining and smelting facilities but operated under the general management of Khaidarkan. With the break-up of the Soviet Union, operations stopped for economic reasons and the mines were abandoned (see Annex 2 for details). According to the Kyrgyzstan's Country Development Strategy (2009), Chonkoy and Chauvay deposits are not planned for industrial exploitation in the foreseeable future.

⁸ Additionally, potential Hg reserves of Kyrgyzstan make 30 thousand tonnes

⁹ The Khaidarkan deposit is defined as quartz-fluorite type with cinnabar ores manifested as jasperoids (a form of metamorphosed chemical sedimentary rock). The Haidarkan ore field incorporates a number of ore bodies composed by sedimentary rocks of Palaeogene-Neocene age and includes limestone, shale and sandstone structures. Industrial mercury ores are related to jasperoid breccia, which are usually found in the fragmentation zones of folds, fractures and advances. Next to mercury, the cinnabar mined in Khaidarkan contains silver, zinc, iron, selenium and thallium. Antimonite is the second industrially exploited mineral after cinnabar. There are also mixtures of arsenic, sulfur, calcite, and other minerals present in the area.

Figure 6 Mercury reserves in southern Kyrgyzstan



Initial ore supply at the Khaidarkan was from open-cast mines, and partly from underground works. However, since the 1970s with the depletion of surface ore reserves, the supply was replaced by the operation of six shafts: No. 16, No. 47, Novoye, Vostochnaya (mercury ore), Zapadnaya (complex ore) and Vspomogatelnaya (mercury ore). Operations at the first three shafts were suspended during the 1990s. Vostochnaya and Vspomogatelnaya are regularly operational while Zapadnaya has ceased its operation due to the stop in fluor spar concentrate production. No. 47 and Novoye still require water pumping to enable mining operations as these two non-operational mines are hydrogeologically interlinked with the also pumped Vspomogatelnaya shaft. The total length of the shafts probably exceeds 400 km. At the peak of production about 10 000 running metres¹⁰ of ore were mined a year, current rates are 1 500 - 2 000 running metres.

Khaidarkan mining operations

At present, around 100 000 to 150 000 tonnes of mercury ore are extracted annually in the vicinity of the Khaidarkan mining company smelting facilities. About 70% is monometallic ore that enters directly the mercury smelting process. The remaining 30% consist of polymetallic ores that undergo milling and floatation for multiple beneficiations (i.e. fluor spar, antimony).

During the Soviet era, the annual volume of ore extraction and processing was 600 000 to 700 000 tonnes, including 80-85 per cent as monometallic ore, with an average Hg concentration 0.12-0.15 per cent and the remaining 15-20 per cent complex ores (fluor spar).

¹⁰ Refers to the length in the shaft that has been mined

Today, selective ore mining provides higher Hg concentrations of the ore 0.2-0.23 per cent supplied to smelter. On the other hand, selective ore mining reportedly led to the rapid depletion and difficulties of accessibility of the future reserves. Geological data produced in the Soviet period has mainly been used up to now and new geological exploration and assessment is critically needed to maintain current or higher levels of production.

Table 3 Mercury production at Khaidarkan in 2000-2008*

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Market value, million Kyr som	120.7	119.4	125.2	139.4	179	188.9	108.4	169.9	140*
Hg, tonnes	550	574.4	541.7	369.8	488.1	303.5	168.9	331.5	270

Sources: Ministry of Industry, Energy and Fuel Resources of the Kyrgyz Republic; Khaidarkan plant

Sources: Bogdetsky (2001); Ministry of Industry, Energy and Fuel Resources of the Kyrgyz Republic (data 1995-2007)

The amount of ore produced by shafts is sufficient to provide only 30 per cent of the full capacity of the smelter (supplied with cinnabar ore) and enrichment factory (supplied with complex ores: mercury, antimony and fluorite). With additional investment, the management of the plant is considering mining ores at the deep horizons (800 m) for mercury reserves explored mostly in the soviet times and currently under exploratory drilling and test mining.

In 2009 experts of the Agency on Geology as well as the mine management stated that depletion of the developed mine areas and the resulting decrease in mercury content was an increasingly serious problem for operations. Even though it is known that significant mercury reserves are located at greater depths or at the abandoned mining sites, the required capital investment to make these resources available is limiting their exploitation. In 2009 Khaidarkan requested 20 million soms from the Government for geological exploration needs. According to the Kyrgyz Mining Association, mining at Khaidarkan could possibly continue for five to seven years before the developed shafts run out, although such forecasts should be treated with caution. It is not known if the Kyrgyz Government has allocated a budget for investing in the mercury exploration but given the economic difficulties the mine is facing, it is rather unlikely.

In addition to ore depletion, another factor contributing to reduced performance is the deficit of professional workers (miners, drillers). In the past, a lot of trained staff with qualification and skills has migrated to neighboring countries where higher incomes can be obtained.

Secondary mercury sources

The Khaidarkan mine, which is technically capable of processing mercury-rich waste, holds the appropriate license and has carried out such work frequently in the past. Over the last two decades the Khaidarkan mine has received mercury-containing waste as feedstock in addition to the mined ore. Waste materials have been imported from Russia, Uzbekistan and the UK for reprocessing and mercury extraction. Khaidarkan received also one to two

loads from Uzbekistan with mercury lamps to facilitate their environmentally safe disposal. As the mercury content in the lamps is relatively low their application in the smelting facilities is not considered an actual source for mercury, rather as waste treatment procedure.

In 2007, one batch of 10 tonnes low-grade waste was imported from Volgograd, Chelyabinsk in Russia to facilitate safe disposal. Khaidarkan received US\$200 per tonne of waste. Another batch of 200 tonnes was received from the Angarsk Chlor – Alkali plant near Irkutsk in Russia. Typical Chlor-alkali wastes are characterized by a mercury content of 3-10 per cent. The selling price at the plant for 1 kg of refined mercury was reported US\$15 per kg. In 2007, almost half of the produced mercury originated from secondary materials. Since this practice has shown to be efficient and difficult mining of mercury ores can be avoided, the company was intended to continue this practice in 2008 but due to complications in supply of mercury waste from the CIS, no contracts had been concluded.

Besides imported waste, Khaidarkan uses its own waste for Hg production. Reprocessing of mercury rich sludge accumulated on site resulted in the production 30-35 tons of mercury in 2007. This is regarded by the management as contribution to the ecological improvement.

It is widely expected that in the long run, mercury recycling will replace mercury production from ore which is increasingly difficult and cost-intensive. The Khaidarkan representatives expressed support for such a solution to the supply problem. Also experts from the Kyrgyz Mining Association and the Ministry of Geology consider reprocessing of mercury-rich waste as the most viable and least cost intensive alternative to primary mercury mining. However, high transportation cost to Khaidarkan make other locations, e.g. China, more competitive for commercial mercury recycling.

Energy inputs

The energy supply at Khaidarkan plant comprises electricity from the Toktogul hydropower plant and natural gas imported from Uzbekistan. Energy supplies are unreliable, which has implications for industrial output: a power cut in 2001 stopped the shaft pumps and caused the mine to flood for several hours. As a result, mining activities were halted for months.

Considering that energy consumption costs make up one third of operational expenses at Khaidarkan, an increase in energy tariffs will have a significant impact on the economic viability of the plant. Uzbekistan's natural gas price for Kyrgyzstan in 2007-2008 was US\$145 per 1 000 cu m, in 2009 it increased to US\$240. In the mid-1990s, the former Kyrgyz Ministry of Economy arranged a barter deal with Uzbekistan to cover natural gas consumption costs, however due to long-standing nonpayment, governmental debt exceeded US\$2 million by 2009. Currently, natural gas consumption is about 3 million cu m per year. The electricity shortage crisis that hit Kyrgyzstan in 2007-2009 has numerous implications for population and local industries, including Khaidarkan.

In view of the serious energy constraints mentioned above, energy consumption for industrial operations became regulated. Compared to the 1990s, electricity use by Khaidarkan has decreased by more than half. The annual electricity consumption in 2007-2008 was about 45-50 million kWh. About 70 per cent of this electricity was used for shaft water pumping. Energy costs amount to 45 million som or about 25 per cent of total

production costs at Khaidarkan. The main energy consumers are pumping stations, compressors, smelter and enrichment section.

The department on regulation of the fuel and energy complex at the Ministry of industry sets the preferential tariffs for electricity while natural gas has no benefits. According to Khaidarkan mine, the company pays 1 som¹¹ (about US\$0.3) per 1 kWh. The tariff applied for electricity use by Khaidarkan is 30 per cent lower compared to industrial consumption. This kind of subsidized price is applied because Khaidarkan supplies pumped water for the local community (non-industrial electricity consumption). The price for electricity is expected to double by 2012, according to a recent government decision.

Water supply

Currently, about 2 million m³ of water is supplied to the Khaidarkan settlement and mining complex from surface (Gauyan) and artisanal sources. In the past, water use by the industry and town reached 4 million m³. A significant amount of water (0.5-0.8 million m³) is produced through pumping water from deep levels of shafts. Outflow from the tailing pond and shaft waters joins the Sokh river, while other discharges (e.g. smelter stream) are land-based.

The water intake is located 7 km upstream in the Gauyan river. The average water discharge into the Gauyan river downstream the mining facility was estimated at 180 l/sec in 2006.

Annual water use by Haidarkan plant:

In 2005 - 1563 thousand m³

In 2006 - 1407 thousand m³

In 2007 - 1297 thousand m³

In 2008 - 1119 thousand m³

5.1.2 Distribution and profitability

Local mercury use

In recent years, informal (artisanal) gold mining has increased in Kyrgyzstan. According to various estimates the number of workers in peak seasons exceeds 5 000 people¹², consisting mainly of peasants in remote mountainous areas, who produce up to 150 kg of gold per year. Most small-scale mining associations and individuals possess only very basic knowledge and gold production skills, using available mineral resources (ref) irrationally.

¹¹ According to other data 0.68 som per 1 kWh (tariff applied for water pumping stations)

¹² It is estimated that in the Jalal-Abad province some 2500-3000 people are involved into small-scale gold mining, while in the Naryn province 2000-2200 people. Each miner produces on average 60 gr of gold per year.

In the Khaidarkan area and the Batken province in general, an estimated 200-300 people are extracting alluvial gold in the Sokh river using primitive methods, mostly gravity sedimentation. In the other parts of Kyrgyzstan small-scale gold mining is frequently assisted by mercury use: on average 5-6 gr of mercury is applied for the production of 1 gr gold. Almost half of all small-scale miners are applying amalgamation resulting in emissions of 200-300 kg of mercury into the environment. The serious environmental risk of water pollution is related to the mercury deposition in river sediments in the areas of intense small-scale gold mining.

Mercury export

Information on the export of mining products from Khaidarkan varies and it is unclear whether sources refer to the final destination of the mercury or merely to traders. The mine negotiates sales arrangements and prices directly with customers and does not include governmental institutions in this process therefore knowledge on this issue is limited. Due to commercial confidentiality and inconsistency of government-supplied data with operator data, the data on mercury production and profit is not available through state agencies.

According to various sources (interviews), buyers of Khaidarkan mercury include China, Russia, Kazakhstan, Ukraine, USA, India and France. The Kyrgyz Ministry of Industry, Energy and Fuel Resources and the Khaidarkan management report that in 2007-8 80 per cent to 90 per cent of mercury products were purchased by foreign firms and 10 per cent to 20 per cent by CIS countries (Russia, Azerbaijan). Kyrgyzstan's national profile for the management of chemical substances (2005) as well as Kyrgyz representatives at the National Forum for the Mercury Action Plan held in July 2009 indicated that China is the major export destination of Khaidarkan's mercury. although during the last few years China has restricted mercury imports and increased domestic production of mercury as its long-term supply contract with the Kyrgyz Republic came to an end in 2004.. Fluorspar concentrate from Khaidarkan mostly goes to Russia (80 per cent), Ukraine (15 per cent) and Kazakhstan. Annual exports from Khaidarkan have been estimated around USD 4 million per year.

Other sources reported that due to the introduction of a new law in China which prohibits the transportation of metallic mercury on its territory, mercury is brought in the form of mercury sulphide, which increases the cost.

The latest information provided by the mine operator, through its commercial office in Bishkek at the State Agency on Geology and Mineral Resources in Bishkek, stated that mercury produced in Khaidarkan is mainly exported to China. The operations are organized through two trading companies with which the mine maintains direct business relations.

Another relevant customer is a trading company based in the Netherlands¹³ which received about 150 tonnes of mercury in 2008 and it is likely this export channel will continue in 2009.

Most of the mercury produced is transported from Khaidarkan to Bishkek by road, passing two high mountain ranges, and then loaded into railroad containers for further shipment via Kazakhstan and Russia to St Petersburg. Though logistically it is easier to transport mercury via Uzbekistan's territory, legal restrictions prevent this possibility.

It is unclear if the global financial crisis will have any significant implications for the global mercury market and Khaidarkan's operations and profitability. In February 2009, Mr M Jumabekov, Batken province's governor asserted that the global crisis is negatively affecting the export-oriented industries of the province, such as the Khaidarkan mercury joint stock company, which faces increasing challenges in selling the available mercury. The value of mercury stored at the industry's stocks in January 2009 exceeds 15 million soms, while outstanding salary payments for the past 3-4 months amount to 9.7 million soms (ref).

There are also known and unreported attempts to smuggle mercury from Khaidarkan to other parts of Kyrgyzstan or abroad. In September 2004 the Osh Office of Civil Defense which is part of the Ministry of Emergencies reported a mercury spillage near the Sarytash village in the Alay Valley of Kyrgyzstan. A site inspection confirmed metallic mercury in the Aryksu river, where children were playing with the spilled mercury. The expert team undertook remediation efforts collecting contaminated soil into plastic bags and disposing of waste at a safe location. No responsibility for mercury spillage was established. To explain the spillage experts suggested it was a failed attempt to smuggle mercury to China.

National relevance

It is estimated that Khaidarkan pays taxes to the local and state budget in the range of 10-15 per cent of income. Since the Khaidarkan is an export oriented enterprise it is VAT exempted.

Table 4 Annual average sum of taxes and payments by Khaidarkan (average 2000-2004)

Tax type	million som
Tax on minerals recovery	2.5
Road and emergency tax	3.4
Profit tax	3.9
Social fund tax	9.2
Withholding tax	1.9
Other taxes (land tax)	0.1
TOTAL	21-22

Table 5 Annual average number of workers (average 2000-2004)

Type of employment	number of persons
--------------------	-------------------

¹³Upon request the company in question denied all relations with mercury transport or trade and Khaidarkan.

Industry workers	977
Indirect employment	437
Induced employment	282
Total	1696

In 2007, 865 people were directly employed by the mine, with more than 100 managers and professionals. The number went down to about 750 people in 2008. The average monthly salary for mine employees is 5000 som.

Table 6 Annual average retained value¹⁴ at Khaidarkan

	million som
Annual local purchases from other companies	36.5
Wage of local workers	3
Taxes	21
Total	60.5
Average sales value	127.2

Profitability

Initially, all mining and metallurgical plants in Kyrgyzstan were corporatized and became open joint stock companies with autonomous accounting and management. The PESAC programme (1994-96) attempted to restructure selected enterprises, including the Khaidarkan.

In 2003 the industry was put on the market for privatization, with a reserve price of US\$2 million, on condition a further US\$6 million was invested over the next three years. Another tender offered a lower price US\$1.5 million, conditional on investments of US\$3 million.

The poor quality of the Khaidarkan assets, including smelter, mining equipment, mineral reserves may be considered unattractive to internationally experienced companies. Mercury is a very particular niche market and Khaidarkan may have substantial environmental liabilities which a new owner would be unwilling to accept.

Representatives by the Ministry of Industry as well as the State Agency of Geology reported that the mine is not receiving subsidies or other types of support. Whether lower energy prices for operations are considered as a subsidy has not been specified. Should the operations at some point produce deficits, it is considered unlikely by both institutions that operations will continue for long since it has been expressed before that there are no

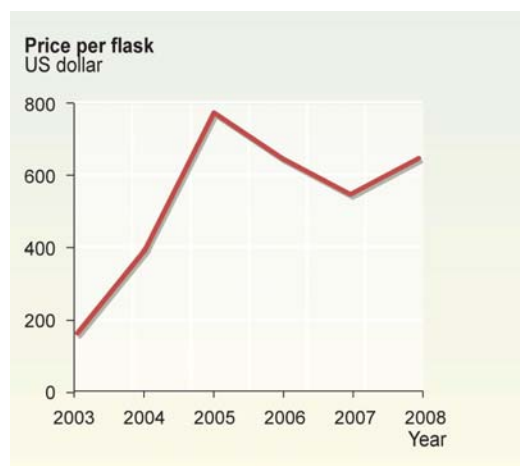
¹⁴ The value added in the country due sell of the final product (export), consists of local purchases and services, wages of local workers and taxes.

possibilities by the state to support the operations. Recent discussions (see section 7.1) have drawn attention to the mines financial liabilities.

As described earlier, the mine is also producing fluorspar concentrate from polymetallic ore. According to the company, processing of complex ores for fluorspar production is mainly unprofitable. The cost of fluorspar concentrate production is about twice as high as the market value of the final product. In 2008, losses generated through this production unit negatively affected financial results of the company. In 2007, this loss was covered by higher mercury production which has dropped in 2008 leading to a overall negative budget in 2008. Taking this into consideration and also the limits for electricity supply, it was decided to stop extraction of the complex ores until the market situation improves.

There is much speculation on the profitability of the mine and no clear or coherent answer was given so far. The Kyrgyz Institute of Economic Policy (2005) analyzed issues related to the transparency of financial reporting among the key mining industries of Kyrgyzstan, including Khaidarkan, in which the institute cast doubts on the existing information regarding profit generation and income distribution.

Figure 7 Average mercury value on the free market per flask (34.5 kg)



For the last few years, the official numbers reported by the mining company show that the operations in Khaidarkan are just breaking even but do not yield any income to the company or state budget. The estimated profit limit for 2000 to 2007 was estimated US\$300-400 per flask¹⁵. Furthermore, the company does not officially report other sources to mercury production such as reprocessing of mercury rich wastes from chlor-alkali plants in Russia.

The MMSD (2001) reported that in the past, when the price of mercury dropped to less than US\$140 a flask, the Khaidarkan Mercury Plant had to introduce a complex exchange system to preserve minimal profitability of the plant. Low world prices of mercury, high transportation costs and low processing capacity (less than 2 000 tonnes of concentrates with processing capacity of 18 000 tonnes) made the formerly prosperous Khaidarkan non-profitable.

In 2002 the net profit of the plant was reported as less than US\$50 000 (total mercury output that year was 125 million Kyrgyz soms, 541 tonnes of mercury), with the plant's authorized capital stock worth an estimated US\$3 million. It has been suggested that during the years in which the mine suffered from a pumping failure that left the mine shafts inoperable, the operations were loss-making. Only in 2007, the business recovered and with an estimated profit of about 3 million Kyrgyz soms (about US\$80 thousand). For the same year, the production costs comprise salaries 28 per cent, electricity 18 per cent, gas 10 per cent. It has been indicated that energy cost (gas and electricity) made up 45-50 million som in recent years.

Production forecast

For 2009, the State Agency for Geology forecasts Khaidarkan output at 240-250 tonnes of mercury with estimated mercury reserves in use sufficient for 5-7 years of operation. Although most of the output of the industry is exported, the benefits gained from the export of production are tempered by the unfavourable geographical location of the country, which is isolated from sea and railroad transportation routes. The ever-rising cost of transportation and energy make it increasingly unprofitable to export all but the most valuable outputs. A substantial increase in production of mercury is possible only by importing raw materials and waste, and/or investment into geological exploration and mining of new ore reserves.

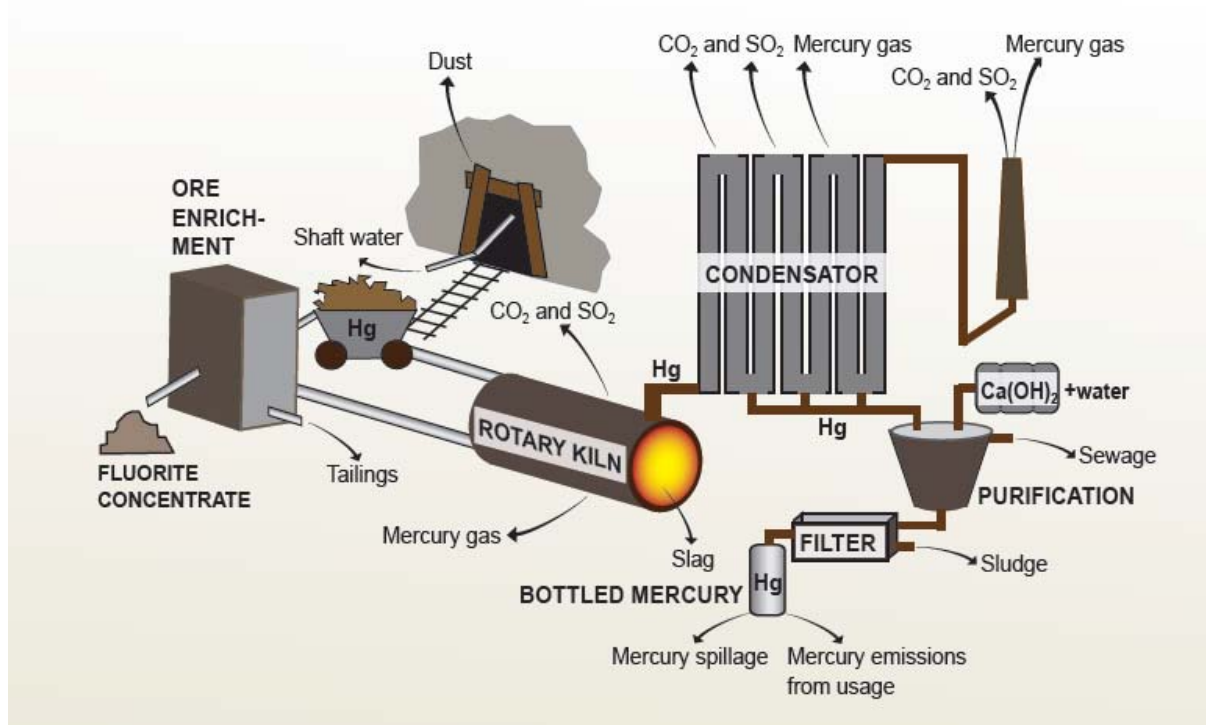
In June 2009, a major failure in the pumping system at the main mercury producing shaft of Khaidarkan occurred, which reportedly led to the flooding of several lower levels of the shaft and suspension of mining operations there. Due to lack of funds, the plant management declared that it cannot fix the problem and appealed to the governmental support.

5.1.3 Technical processes

Process overview

Due to the very low evaporation temperature compared to other metals, mercury extraction is a relatively simple process. Once the ores or other raw materials are provided, a very high purity of mercury can be achieved in Khaidarkan. Figure 8 (next page) shows how the basic process functions and which mercury related emission arise at which stage of the beneficiation.

Figure 8 Khaidarkan mercury production scheme and emission points



Cinnabar mining

The Khaidarkan mines comprise 8 horizons and are up to 400 metres deep. At present, the ore extraction is mainly conducted at deep horizons. Two of four shafts¹⁶ in Khaidarkan are currently mined:

- Underground mine #1, specializing in mercury ore extraction
- Underground mine #2, specializing in complex ore extraction

On average, the mines produce around 100-150 000 tonnes of ore per year, on average 220 tonnes a day. Over the past three years, the mercury content in mined ores was around 0.25-0.29 per cent (1 tonne of ore provides about 2 kg of mercury).

The underground works #1 (RRP-1) specializes in the production monometallic ore with an annual volume of 150 thousand tons of ore. All upper horizons are developed. 275 people are employed in the operation of this shaft. It includes the shafts: Vostochnaya, Vspomogatel'naya, Novaya, 47. Currently, mercury ore mining is mainly implemented in the deep levels.

Vspomogatel'naya shaft reaches depth of 400m, and has eight levels of production. The static water level is approximately at a depth of 260-300 m, due to karstic water intrusion the deep levels the shaft is constantly flooded and requires continuous dewatering. The mine operates water pumps with 500 kW at this location to sustain the mineral extraction.

Vostochnaya shaft operated at three levels with a depth of 240m.

¹⁶ Drilling and blust methods are commonly used

The underground works #2 was established in 1989 and specialized in the extraction of complex ores at the Zapadnaya shaft. About 142 people are employed at the shaft of which 124 are mine workers and 18 engineers.

The deepest levels of the shaft reach 580m. Most equipment is in working condition. The original production plan was 300 thousand tones of ore per year, but the actual capacity is around 100 thousand tons. At the moment, Zapadnaya shaft operations are suspended due to financial constraints.

The UNEP/GRID-Arendal team visited the Vspomogatel'naya shaft at 400 m depth and confirmed the intense karstic water discharge at 240 cu m an hour (66 litres a second). Other shafts also require water pumping which results in total up to 800-1 000 cu m a hour. The static water level is approximately 300 m below the surface. In 2001, following a six-hour electrical outage, the shaft was flooded and it took more than two years to restart operations at the lower levels. Beyond such interruptions that almost led to the closure of the operations, the ongoing extensive energy cost for pumping these amounts of water 400 m to the surface is a big financial burden for the operations.

Plans to tap new deposits (mainly discovered during the Soviet era) at 800 metres depth are being considered by the plant's management.

Smelting operations

The mercury smelter processes the cinnabar ore delivered from underground mines as well as enriched ore from the nearby concentration plant which mainly produces fluorite concentrates. About 100 people are currently employed in this unit.

The smelter has two main sections: eight rotary kilns for cinnabar ore and a boiling bed for mercury-concentrate. The mine reports that two to three rotary kilns are operating.

After mechanical crushing in three sections, the raw material undergoes a roasting process in the rotary kilns, equipped with natural gas burners. Crushed ore with a moisture content below 5 per cent is fed into the rotary kilns that have total capacity of 320 tons. While ordinary ores are processed in kilns #1, 5, 6, 7, 8, the mercury-rich ores are processed separately in kilns # 3 and 4. Kiln #2 is only used for secondary products such as sludge and ashes from the central gas pipe. The temperature at the start section of the rotary kiln is between 1000°C and 1200°C towards the end it declines to 500°C. Each rotary kiln can process about 40 tonnes of ore an hour¹⁷.

The kilns operate according to the counter flow principle in which mercury and other materials are fed towards the burning gas. The ores are subjected to oxidation at temperatures around 700-900°C whereby mercury and other compounds are volatilized. Afterwards, the gases are sent to the condenser to extract mercury in the cooling process. Metallic mercury deposits together with dust and combustion products in the condenser. This

¹⁷ There are 8 rotary kilns operating in Khaidarkan. Rotary kilns # 1, # 5-8 are used for normal concentration ore processing; # 3-4 are used for rich ores and # 2 for hg-containing sump, sludge, and other exhaust products etc.

mixture is collected from the there every 3-10 days. The resulting mercury product (category R-3) contains a significant amount of mechanical and organic impurities therefore a purification process is following the smelting. The mercury is sent into a cascade of glass containers in which the mercury is freed from impurities by subsequently treating the metal with alkali solution (10 %), distilled water, a solution of nitric acid (10 %) and eventual dehydrated with ethanol. The mercury extraction rate in the rotary kilns is around 90 per cent. After refining, the final product is 99.99 per cent pure mercury. Mercury rich wastes such as the sludge from the filtering section are returned to the rotary kiln for reprocessing. Eventually all solid wastes, such as sludge and mine waste, are disposed of at the enormous waste dumps that have accumulated around the smelter over the past decades.

Exhaust gases at the end of the condenser should not exceed 30°C in order to capture mercury effectively and avoid mercury emissions through the stack. Identified environmental criticalities are poor isolation of the rotary kilns (and as result they serve as major atmospheric emission source) as well as leakages/spillagages of mercury in the operation area. Significant emissions are also created during the startup and shutdown of the process. As the smelter is used only several hours per day, this further increases the overall mercury load released into the atmosphere.

The rotary kiln consume 27 m³ of natural gas per tonne of ore with a daily consumption 6000-8000 m³ of natural gas. The electricity use by the smelter is 6000-7000 KWh per day.

Economic hardship and lack of governmental support have left the smelting operations with little or no investments in modernization or refurbishment of the plant. Only one of the eight rotary kilns is operational and significant losses of mercury to the air can be attributed to the poor sealing of the remaining rotary kilns (see following chapter). The condenser, which is responsible for separating mercury from the flue gas by cooling down and condensate mercury in the tubes, operates with ambient air instead of water or other more efficient cooling agents. As mentioned above, flue gas needs to be cooled below 30°C in order to minimize mercury emissions.

Ore enrichment section

Ore-enrichment plant is capable of processing up 100 000 tonnes of ore a year. Most equipment is operational, but requires refurbishment.

In this process lower grade mercury ores that are combined with other materials are enriched by going through a milling and flotation process which yields higher mercury concentrations in the raw material. The product is regularly tested for its mercury content. If it reaches a certain concentration, the batch is directed to the mercury production unit (boiling bed section) for mercury extraction. About 400-500 tonnes of Sb-Hg concentrate are produced annually. About 71 people are employed at this facility.

Other products

In 1968 the Khaidarkan Mercury Plant began producing a concentrate of fluorspar which had been extracted along with mercury on the Khaidarkan deposit. Since 1986 production has amounted to 200 000 tonnes, with productivity in 1997 at 14 500 tonnes (MMSD 2001).

Currently, 1 000 to 3 000 tonnes of fluorite concentrate are produced annually, but with low economic viability. It has been reported that the fluorite production is not profitable and supported by the mercury sales.

Fluorite and antimony-mercury concentrate is produced separately from mercury smelting in a concentration process that accounts for all the tailing material at the site.

6 Environmental conditions and concerns

6.1 State of knowledge

In 1990, it was concluded by the USSR Ministry of Metallurgy (as stated in the Ecological Passport) that many years of mercury production had led to a critical ecological situation at the site, forcing controlling agencies and sanitary-epidemiological services to take immediate response actions or close the plant. However, it was considered unlikely that closure of the plant would significantly change the situation since historical pollution in the area is a serious problem. Emission reduction measures and clean up of historical pollution has been considered as urgent and important task but their practical implementation was inhibited by the lack of appropriate financial resources and “a series of organizational, technological, and environmental issues”.

Today, Khaidarkan does not publicly report on its environmental performance. In spite of public concerns over environmental situation and potential risks from the hazardous waste virtually no data on emission of pollutants and waste, pollutant concentrations and hazardous areas is available to the public, nor are any independent audits.

Figure 9 Situation of the Khaidarkan mining plant



6.2 Pollution sources

During mercury production and related activities several emissions of mercury and other pollutants to the environment occur. The figure shows main identified emission points of gaseous, liquid and solid emissions during the production process. The following sections characterize these emissions and estimate their environmental impact.

It must be noted that original sampling was carried out during the project. While only a limited number of locations and media could be analysed, the two sampling campaigns carried out in July and October 2008 provide an updated screening of the local conditions. This data supplements analysis conducted by the Uzbek Republican Department of the All-Union Scientific-Technical Society of the Non-Ferrous Metallurgy for the Ministry of Metallurgy of the USSR in 1990. The data was presented in the so-called Ecological Passport of the plant that is still required for all industry facilities in Kyrgyzstan. The document provides information on environmentally relevant activities, discharges and specific emission limits imposed on the plant. Although Khaidarkan is obliged to renew the Ecological Passport every five years, no document of this type could be identified. The document quoted in this report is the Ecological Passport prepared in 1990 and therefore represents the environmental impact during the industry's peak production years. The tables in the Annex 1 also include information on the formerly active mercury mines Ulug-Too and Chauvay which have been administered by the Khaidarkan enterprise.

The old data are of limited validity today, since the number of employees as well as production levels have shrunk to about a third compared to the late 1980s. However, qualitative information such as pollution sources and waste composition are still comparable and there is high value in knowing the upper limits of environmental pollution at the mine.

6.2.1 Air emissions

Mercury's low evaporation temperature and the long lifetime of gaseous mercury make airborne transport the most relevant contamination pathway for mercury emissions. Among the main emission sources for gaseous mercury in Khaidarkan are the rotary kilns, the smoke stack but also reemission of mercury deposited in the environment

In the rotary kilns, mercury is evaporated from the ore between 500 and 1200°C. The gaseous mercury is then supposed to flow in the condenser where it cools down and precipitates. The sealing of the rotary kilns is playing a vital role in maintaining the mercury gases within the production system. In Khaidarkan, the applied equipment for this process appears to be outdated and of critical condition.

Table 7 Mercury release at the Khaidarkan metallurgic plant in mg/m3

Site	1983	1984	1985	1986	1987	1988	1989
rotary kiln # 2	0.112	0.092	0.097	0.087	0.098	0.101	0.079
Hg storage room	0.113	0.106	0.115	0.098	0.093	0.081	0.05
Operating area	0.087	0.067	0.085	0.096	0.090	0.091	0.05

Source: Khaidarkan Ecological Passport, Ministry of Ministry of Metallurgy of the USSR, 1990

After the flue gas has passed the condenser, all discharges are released to the atmosphere via a central stack. The Ecological passport states before 1990, gaseous waste contained 15-20 mg/m³ of mercury vapour. With the integration of a poly-sulphate Hg absorption method in 1990, the mean mercury vapour concentration decreased to 5-10 mg/m³. Mine representatives stated that gaseous Hg concentrations at the site were around 30-40 mg per cubic metre during peak production levels. At current production levels they are reported by around 10 mg.

The mine reported that in the late 1980s an electric filter was installed to capture heavy metal releases. After a short while, a failure of the filter occurred and it has not been in use ever since. Installed the aspiration capacity of the electric filter is 70 000 cubic metres per hour. Today, about 10 000 tonnes cubic metres per hour are discharged therefore the available equipment could not be used effectively even if functional.

Stack emission and air pollution sampling require specific equipment and capacity in conducting such analyses. For the purpose of this assessment, such capacities could not be identified in Kyrgyzstan or mobilised elsewhere.

In order to approximate current emissions, data of the Ecological Passport can be used as a basis for rough indications about the air emissions from rotary kiln and stack. Therefore, it must be assumed that mercury emissions correlate with the amount of mercury produced and that equipment and technical conditions remain similar to 1990. In reality, they are likely to even have further deteriorated since no major refurbishments or investments were reported.

Table 8 Reported emissions by Khaidarkan

Pollutants	Agreed emissions tonnes per year	Actual emissions in 2007 tonnes per year
Sulphur dioxide (SO ₂)	390.7	136.8
Carbon monoxide (CO)	438	167.6
Elemental mercury (Hg)	2.7	2.7
Nitrogen oxide (NO _x)	26.9	26.2

Source: Environmental department of Khaidarkan mine

When comparing today's production level of about 300 tonnes in 2008, with those in 1990 when 14.6 tonnes of mercury were released into the air for producing 800 tonnes of product, it can be calculated that about 5.5 tonnes of mercury were emitted in 2008, assuming that there is a direct correlation between mercury production and pollutant emission. It should be noted that this figure is more than twice as high as the reported figure for air emission at Khaidarkan which is 2.7 tonnes per year as indicated by the Environmental Department of Khaidarkan mine. Further verification of information will require thorough analysis and air sampling. Local experts suggest under-reporting of air emissions by the Khaidarkan mine due to its weak laboratory base, shortage of qualified environmental staff and unreliable reporting system.

Release of heavy metals, metalloids and large amounts of greenhouse gases are other pollutants released into the environment during mercury production. Because of its mineral riches, ore mined in Khaidarkan comprises various other potentially toxic agents such as antimony or cadmium which are easily vapourised at rotary kiln temperatures. Unfortunately, there is currently no data available on air pollutants other than indicated in Tables 7 and 8.

Previous analysis for the Ecological Passport in 1990 stated that weather conditions and prevailing winds have significant relevance to the level of mercury contamination in relevant areas such as Khaidarkan town. Unfortunately, the prevailing wind direction is from east to west which coincides with the location of the town towards the plant. Furthermore, it has been noted that the large height of smelter smoke stack (about 200 m) contributes to areal dispersion of the contaminants which results in lower concentrations in the vicinity of the plant but to a greater affected area.

Limited recent surveys conducted by the Kadamjai SES indicate the atmospheric mercury concentrations in the residential area ranging from normal to slightly elevated levels.

Together with the smelter slag, tailings materials which are located in a dam west of Khaidarkan town are the main concern for dust formation. During the dry period dust curtains that disperse across agricultural land have been described as the main environmental concern by the State inventory/cadastral sites of the Kyrgyz republic.

Another long term concern is the re-emission of mercury previously deposited in soils and other surface materials. Mercury can be emitted from terrestrial surfaces to the atmosphere, and deposited to terrestrial surfaces from the atmosphere by wet and dry processes. After deposition Hg can be subsequently re-emitted back to the atmosphere. One of the large uncertainties in quantifying Hg emissions from terrestrial surfaces is distinguishing between Hg originally present in the substrate and Hg deposited from the atmosphere and then re-emitted. Previous studies in other regions where mercury has been emitted from a point-source showed that even after the source has been eliminated, atmospheric mercury levels remain elevated due to this process (ref Slovenia, Spain).

6.2.2 Mercury rich waste

During the mercury production process, several waste streams occur which contain different levels of mercury and other pollutants.

Slag

About 85 per cent to 95 per cent of the processed ore results in slag which is solid waste material that exits the rotary kiln after the burning process. It is a grey sand-like material of which about 13.3 million tonnes are currently deposited on an area of 39 ha around the smelter and the settlements. According to data supplied by the plant, the deposited slag contains about 5 mg/kg mercury. However, slag analyses conducted by the project team in 2008 showed that the average mercury concentration is around 200 mg/kg. The range of mercury concentrations in the slag is estimated between 0.001 to 0.05 per cent.

According to the National Health and Environment Action Plan (NEHAP) produced by the Kyrgyz Ministry of Health and the Ministry of Environment Protection in 1998, the stored wastes violate nature-protection rules and present a direct threat to the environment and the population.

There are plans by the mining company to make use of the waste by building a cement plant with capacity of 600 000 tonnes a year. Although the economic feasibility study for this scheme has been recently completed, further environmental studies may be required to determine the risks and benefits related to producing cement from slag waste.

Tailings

Tailings are another waste type generated during the concentration process of fluorite ores which occasionally also yield mercury concentrates for processing in the smelter. Tailings look similar to slag but are finer and more homogenic in terms of grain size. Unlike slag, tailings do not undergo thermal treatment. Instead, they enter a chemical process in which they interact with flotation and coagulations agents and other chemicals. Materials discharged in the pond consist mainly of quartz, fluorite and other accompanying elements such as Hg, Sb, As and Zn. Tailings are in suspension with water when deposited and require appropriate containment structures.

In Khaidarkan, tailings pond is located in the Zarhar valley at an elevation of 1681 m at the bottom and 1705 m at the top with steep slopes (average floor inclination 0,033). The bottom of the valley consist of gravel sediments and soils, the valley sides are composed of limestone and deluvial deposits as well as indigenous rocks. The groundwater level in area of the facility is 100-150 m.

The total surface area of the storage facility is 22.6 ha while the dam itself is 1200 m long with a minimum width of 5 m at the top. It mainly consists of gravel material and local soils, without an underlying screen or dull. The tailings are conveyed from the factory down a pipe (diameter 219 mm, length 5 500 m) to the pond where they are further distributed via additional circular pipelines along the perimeter. The tailings facility comprises a complex system of hydraulic transport and deposition, combined with 'on-the-way' waste-water treatment in which the tailings are transported by gravity over 5500 m from the plant to the tailings dam. The purification of the waste is arranged before discharge with sulfur-acid aluminum (150 mg/l) and lime. The reaction takes place in the waste water pipe and via sedimentation in the tailings pond itself. The pond surface rises about 0.6 m per year.

Operations at the tailings pond started in 1968. It was designed by the Kazmehanobr engineering institute (Alma-Ata, Kazakhstan), which was tasked with the regular supervision of its state during the Soviet era. Due to bad economic situation and lack of funds, the current status of the tailing does not comply with legal requirements. There are no protective fences and no environmental monitoring is conducted. However, the company reports that staff is present and constantly monitoring the pond.

About 4 million tonnes of waste have accumulated in the tailings pond across an area of 22.8 ha. The total capacity is 8.5 million tonnes 47 per cent of which is currently used. The plant reports the following chemical composition for the suspension:

- mercury 0.003 mg/l
- antimony 21.5 mg/l
- fluorite 6.7 mg/l

Tailings analyses conducted on behalf of UNEP/GRID Arendal in 2008 yielded 126 mg/kg mercury in the dry material. During the REHRA project conducted in 2005 which focused on the analysis of the Khaidarkan tailings pond, the average mercury content in the dry tailings is 126 mg/kg. The analysis revealed that the waste pond and its superficial layers contain large quantities of hazardous chemicals (mercury, antimony and arsenic), with a prevailing pathway of contaminant distribution by air (dust and wind).

There are clear signs of farm animals entering the pond to drink from the accumulated water. Furthermore, local farmers repeatedly expressed their concerns over water quality impacts from waste seepage and dust formation at the tailing during dry periods.

Sludge and waste water

During the process of mercury purification waste water and sludge are generated and discharged into primary treatment (sedimentation). Overflow is further discharged in to an evaporation pond. After liquid components are removed, mercury rich solids are returned from both the sedimentation and the evaporation pond to the rotary kiln for mercury extraction. Wastewater from the metallurgic plant has no connection to other industrial wastewater.

There are four sludge collectors which accumulated around 4 000 tonnes of dry sludge in total. The overflow (3-5 l/s) from the sedimentation basin in the smelter flows for several hundred metres without any safety measures or bottom lining along the waste piles to the evaporation pond. Cattle have been observed drinking from the discharge during the expert visits. This stream was among the several sampling points for potentially contaminated water. According to company analyses, industrial wastewater (liquid sludge) contains mercury 0,001 mg/l, sulfates 0,023 mg/l, chlorides 15 mg/l. However, analyses conducted during this study in 2008 yielded 14 mg/l mercury in the wastewater. All other water samples in this study did not indicate considerable mercury concentrations¹⁸.

6.3 Areas of concern

The main contamination pathways for human exposure of toxic materials are air, water and soil which are analysed in the following chapter. Data therefore was generated in the course of the project and is completed by previously conducted analyses.

¹⁸ Sensitivity of analysis equipment was until 0.0005 mg/l

Samples have been taken during the site visits at points where critical mercury contamination was suspected such as in waste materials and in mediums of concern such as water and soil. Therefore, several agricultural soils in and outside the main wind direction have been sampled. Water from the two rivers in the Khaidarkan area has been collected at critical points such as before and after the discharge of mine water, at the drinking water intake for Khaidarkan town and at the irrigation water intake. Furthermore, locally produced food such as apples, carrots and potatoes have been analysed for mercury content. In order to be able to distinguish between background value and mercury pollution created by the mining process, reference samples have been taken and analysed in areas expected to be largely unaffected by the mine.

It should be noted that the mercury concentration in environmental compartments depends largely on weather conditions and seasonal timing. Due to the limited sampling, this analysis can only represent a rough screening of the local conditions. There is also a need for more suitable analysis equipment which will also be required for proper monitoring and enforcement of mercury related regulation.

6.3.1 Air

Since no original air sampling and analyses could be carried out in the course of the project, this section draws largely on information provided by the Kadamjai Sanitary Station which regularly conducts air analyses in the region.

Historically, high air concentrations of mercury were observed in 1988, 1989, and 1990 when regular emission measurements were actually made. As a consequence of the high pollution levels, the sanitary station constructed the section on aspiration and sanitary cleaning.

In the late 1980s, a seasonal complex research of atmospheric mercury pollution had been conducted within the industrial facilities, residential areas and areas of slag waste deposition. The maximum concentrations were observed during warm weather. Solid proof of increased mercury concentrations and secondary emission from previously deposited mercury in the area was confirmed by sampling after a two-day operational break at the metallurgic plant in April 1987, when the smelter emissions were mostly limited. Under such conditions average mercury concentrations in the air in the smelter area were 0.049 mg/m^3 , and 0.0006 mg/m^3 in residential areas which shows that mercury concentrations remain significantly elevated even during operational breaks.

During the analysis, the highest mercury concentrations in Khaidarkan town were measured when winds came from the eastern direction, where the smelter is located. The values in Khaidarkan town ranged from 0.0003 to 0.0042 mg/m^3 .

Today, the Kadamjai Sanitary Station reports that in Sur village, about 8 km west of the smelter, no excessive air concentrations of mercury are being measured. In Khaidarkan however, average mercury levels are about 3 times higher than in Sur and sometimes exceed the Kyrgyz limit value of 0.0003 mg/m^3 .

6.3.2 Soil

Agricultural production is limited in the Khaidarkan area due to low soil fertility and mountainous terrain, but as can be seen on sat.map (fig 9), significant areas in the proximity to the mercury production facilities are used for crop production. The following table shows that agricultural soils display considerable mercury, lead and antimony pollution, exceeding Kyrgyz limit values.

Table 9 Soil analysis in 2008

Sampling site	Distance to smelter	Cd	Hg	Pb	Sb	Se
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Khaidarkan						
Agricultural soil	0.5 km south	0.6	14.5*	18.9*	59.7**	6.4
Agricultural soil	1 km west	1	9*	22*	52**	<1.5
Agricultural soil	2 km west	0.4	25**	16*	20*	<1.5
Agricultural soil	3 km west	0.3	10*	20*	32*	<1.5
Agricultural soil	8 km west	0.6	14.5*	17.8*	40.4*	5.8
Sediments, Gauyan river	5 km south (upstream)	<0.25	7.2*	<3.5	<2.5	5.2
Sediments, Gauyan river (near to UZB border)	8 km north –west (downstream)	0.3	43.9**	22.1*	98.1**	4.9
Soil	3 km south	0.4	6*	19*	4	<1.5
Soil on mountain pass	5 km east	0.4	2	16*	<2.5	<1.5
<i>Continued</i>	Distance to smelter	Cd	Hg	Pb	Sb	Se
Ulug-Too						
Agricultural soil	2.5 km south east	0.3	1	18	<2.5	6
Reference soil	80 km	1	1	24	3	<1.5

*exceeding Kyrgyz limits by a factor <10

**exceeding Kyrgyz limits by a factor >10

6.3.3 Water

Mining operations have a large impact on the water availability in Khaidarkan caused by the extensive pumping of mine water to maintain the shafts accessible. Today, about 1000 m³ water are discharged to the surface per hour. Shaft water contributes to the availability of irrigation water and is considered indispensable for the continuation of agricultural activity in the area.

Water analyses have not shown any detectable mercury concentration in natural waters. Methylation of mercury at relevant levels is considered unlikely. However, it should be noted that the instruments used for this analysis display only limited sensitivity with a detection limit similar to the Kyrgyz threshold value for mercury. Due to low water solubility of inorganic mercury, its concentration in natural waters is often low while significantly higher concentrations can be found in river sediments. A similar experience has been made in this analysis. Although no mercury could be detected in the river water samples, the mercury concentration ranged between 7.2 mg/kg upstream and 43.9 mg/kg downstream from the

mercury plant, in sediments found in the Gauyan river. The almost six-fold increase of mercury downstream compared to the upstream samples points out the mercury plant as the main source for mercury in the river.

High concentrations of antimony were found in samples of tap water in the Khaidarkan (75 mg/l). For comparison, the Swiss limit value for antimony in drinking water is 5 mg/l.

6.3.4 Foodstuff

During the research, no historic foodstuff analyses could be identified. Tests conducted with potato, carrot and apple samples collected by the project team showed mercury values at the level of the Kyrgyz values.

Table 10 Foodstuff analysis in 2008

Type	Cd	Hg	Pb	Sb	Se
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Potatoes	0.01	0.01	0.10	< 0.1	< 0.1
Carrots	< 0.1	0.06*	0.10	< 0.1	0.10
Apples	< 0.1	0.01	0.10	< 0.1	< 0.1

* Kyrgyz limit value

The obtained data are difficult to interpret since only one analysis has been conducted per vegetable. The Kyrgyz legislation maintains a limit value for vegetables 0.06 mg/kg, although the carrot sample almost exceeds this value, it will require further analysis to determine if the quality of foodstuff produced in Khaidarkan is affected with mercury pollution.

6.3.5 Human health

The number of health studies conducted in the region is very limited and existing documentation is unavailable or could not be located. However, some limited information is available but neither the methodology nor quality of these studies could be verified. The Ecological Passport (1990) gives information on patients for various diseases, but it makes no comparison to other communities or if some diseases are linked to mercury pollution.

Table 11 Health conditions in Khaidarkan, Ecological Passport 1990

<i>Health issues</i>	Adults and teenagers (Number of registered patients)	Children up to 14 years (Number of registered patients)
Infections and parasitic diseases	351	692
Neoplasm	57	-
Endocrine diseases	89	287

Mental disorders	156	3
Nervous system diseases	548	192
Respiratory diseases, total:	1574	1630
including dust bronchitis	25	-
Musculoskeletal diseases	694	3
Mercury intoxication	33	-
White fingers (vibration disease)	87	-
TOTAL	5691	3232

According to data of the Khaidarkan hospital, the recent pattern of disease (in 2007) is dominated by the following disorders: urinal-genital system, 13.5 per cent (371 cases); circulatory system, 9.9 per cent (271 cases); respiratory system, 9 per cent (248 cases); and gastro-intestinal 7.8 per cent (216 cases). Circulatory and respiratory diseases are the lead causes of death (50 per cent and 22 per cent). Diseases among Khaidarkan plant workers feature respiratory diseases (26.5%), diseases of bones and muscles (14.4%), skin diseases (7.2%), cardiovascular diseases 16.6%.

Table 12 The incidence of selected diseases in the population of Khaidarkan

<i>Incidence of diseases</i> ¹⁹	Data from SES Osh: control settlement Uch-Kurgon	Data from SES Osh: exposed settlement Khaidarkan	Data from Khaidarkan hospital	Data from Khaidarkan hospital
Year	1992*	1992*	2006**	2007**
Nervous system	-	-	3.2	2.4
Endocrine	-	-	6.9	6.5
Gastro-intestinal	18.1	39.1	9.7	11.4
Urinal and genital	11.1	13.1	12.7	10.1
Skin	13.9	15.6	5.1	5.9
Skeletal and muscles	3.1	40.3	6.1	5.2

Sources: * National Environmental Action Plan (1994); ** medical statistics obtained from the Khaidarkan hospital (July 08)

Child health

Adambekov and Sulaimankulov (2002) studied the 'Immune Status of Children in the mercury Biogeochemical Province of Southern Kyrghyzstan'. The results of the study show that essential variations in the parameters of the immune status were detected in persons living near the mercury combine, where the mercury concentration in the free air was significantly higher than the marginal concentrations.

About 46 women and 126 children of the preschool age were examined who had no contact with the production of mercury. Mercury was detected in the placental blood in all inspected

¹⁹ Commonly, incidence of diseases is measured per 10,000 people. Units provided in the table required clarification.

persons at concentrations ranging from 0.84 to 28.22 mg/ml with an average concentration of 5.88 mg/ml. A mercury concentration of at least 10 mg/ml was found in 80.4 per cent of all inspected individuals, from 10 to 18 mg/ml – in 15.2 per cent and exceeding 20 mg/ml – in 2.2 per cent of inspected individuals. Concentrations of mercury in the breast milk of women were 1.4 times higher than those of women in the control group.

Immune changes in the organisms of children were accompanied by immunodeficiency and reduction of the immune-regulating coefficient. Child morbidity in the area is mostly associated to respiratory diseases, blood generation (hemopoiesis) and infectious pathology.

Occupational health

A limited number of cases of mercury intoxication of miners have been reported in the past. For non-miners there are no confirmed cases. This information should be handled carefully since it can be linked to an absence of regular examinations and access to proper medical care for this population group. Also there might be underreporting of such cases for various reasons. Also there is no informal information such as rumours about negative effects from the mercury production. Another factor that might lead to a lack of reported cases can also be high fluctuation in population, especially workers and engineers of Slavic origin in the past 15 years.

Analysis of occupational diseases in the past 15 years shows that the main industrial factors affecting health of workers are vibration, temperature, noise, dust and exposure to mercury. However, evident impacts of mercury on the population as a whole are not detected. The Ecological Passport (1990) reports that typical occupational diseases are “white fingers” (4 cases a year), mercury intoxication (1 case a year), silicosis and dust bronchitis (1 case each per year). In 1990, there were 120 workers registered with occupational diseases at Khaidarkan, including 27 suffering from mercury intoxication.

Table 13 **Reported occupational disease rate for Khaidarkan**

Year	Total	Health issues:		
		Vibration disease	Bronchitis	Mercury intoxication
1991	34	14	11	9
1992	29	10	15	4
1993	27	11	9	7
1994	7	1	4	2
1995	5	2	3	-
1996	6	3	2	1
1997	1	1	-	-
1999	7	4	2	1
2000	8	5	2	1
2001	9	8	1	-
2002	3	-	2	1

2003	2	-	1	1
2005	5	4	1	-
2006	8	2	6	-
TOTAL	151	65	59	27

Dominant occupational diseases are dust bronchitis, Raynaud's phenomenon, intoxication

Source: National sanitary-epidemiological station

Doctors working at the Khaidarkan hospital are responsible for providing regular medical services to the personnel of the various parts of the mine (shafts, smelter) and compiling annual reports on workers' health, which are submitted to the plant's management and to the provincial medical statistics centre in Batken. In addition, the mine's management is obliged to report health-related data to the Kadamjai Sanitary-epidemiological station.

It was reported that the Khaidarkan plant currently spends 1.8 million soms a year on the social and medical welfare of workers. The preventive medicine centre which provides physiotherapy, various medical services and advice on a balanced diet has a capacity of 50 patients (annual treatment of 500 people). Reportedly, the centre helps to improve working capability and reduce the rate of disablement leave and sickness by 30 per cent. Every year 20 to 30 workers are sent to spas at Issyk-Kul, Issyk-Ata and Jalal-Abad. Shaft workers receive a daily ration of 0.5 l of kefir.

The radiology department of the Sanitary-epidemiological service at Osh is responsible for radioactivity monitoring. In the Khaidarkan area, including the industrial complex, shafts and tailings, radiation levels are reported to be normal (up to 15 micro R/hr). Only in geological layers with predominant shale rocks are radiation levels slightly higher.

6.4 Conclusions

6.4.1 Local contamination

Pollution levels detected in the course of this study show that levels of mercury and other heavy metals in soils and sediments are elevated and exceeded limit values as specified by the Kyrgyz regulation. Mercury could not be detected in natural waters, which is as expected due to its low solubility in water.

Very high mercury concentrations were identified in slag, sludge and tailings which are stored in the proximity to human settlements and agricultural land without appropriate containment measures in place. Mercury rich waste materials are subject to wind erosion especially during dry periods which appear to affect nearby settlements and agricultural land.

Information on ambient air quality provided by the Kadamjai Sanitary Station showed that Kyrgyz MAC values are regularly exceeded. There were no recent analyses of the smelter's mercury emissions but assuming that emissions are proportional to the production levels,

current emissions would be around 6 tonnes per year compared to the emissions measured in 1990, while the officially reported figure is 2.7 tonnes of mercury emissions per year.

Locally stored wastes violate nature-protection rules and present a direct threat to the environment and the population

Key priorities for risk reduction and environmental mitigation should be securing the main pollution sources which have been indentified in this assessment as:

- Mercury smelter and sludge sedimentation tank: in particular emissions from the rotary kiln, stack emissions & process water from the mercury precipitation process;
- Slag heaps: to avoid wind and water erosion and limit accessibility;
- Tailings dam: to avoid wind and water erosion, water seepage and to limit accessibility

Secondary mercury emissions from mercury deposited in the natural environment also contribute to elevated mercury levels in ambient air. Even if mercury production stops in the area, this source of air pollution will remain.

6.4.2 Environmental monitoring

In general, the lack of proper monitoring, suitable measuring equipment and local capacity in conducting sampling campaigns makes efficient emission control very difficult in Khaidarkan.

Environmental authorities have no means to verify data provided by the industry which may result in support for improper reporting. This is further aggravated by the absence of an environmental management plan, target values and inventory of emissions (e.g. Ecological Passport or more advanced regulatory document) which is required by legislation. After the Ecological Passport in 1990 was issued, no more independent and comprehensive analysis of emissions is available. There are doubts that such documentation has been prepared in the last 15 years.

The absence of reporting requirements and strict emission control limits hampers monitoring and incentives for limiting mercury emissions. It is assumed that this development contributed to the fact that no major environmental protection measures have been implemented for years.

6.4.3 Technical requirements

As described, there are various sources of environmental pollution at the mining site that result in considerable pollution levels in the area. It must be noted that due to the historic pollution, mitigation measures will not lead to immediate reduction of mercury levels in air and soil due to secondary mercury emissions and re-deposition of compounds already present in the environment. However, there are measures that can reduce further entry of pollutants into the environment and put a halt to continuing aggravation of the situation. It is recommended to investigate such measures and apply them as soon as possible.

The main source of mercury pollution is the smelter which releases roughly 3-6 tonnes of mercury into the atmospheric air. By investigating options that increase efficiency of the smelting process, these emissions can be turned into additional value for the mining company. The most dominant source for these emissions is leakages at the rotary kilns.

By increasing the efficiency of the condenser (which is responsible for extracting mercury from the flue gas) similar benefits can be gained. This can be done by improving its seal or lengthening the condensation path.

Electric filters, as previously installed at the site, are very useful when the dimension of the filter and the amount of flue gas to be treated are compatible. In Khaidarkan, the filter is too big and therefore cannot operate properly. Also, electric filters demand considerable amounts of energy which can be costly. As long as most of the emissions occur at the rotary kiln, reinstalling a filter at the smoke stack would only be of limited value unless all the gases pass through the device. This would require a collection system for the escape gases which would further add to the cost.

Improving handling of mercury products (proper containment) and slag, e.g. proper cooling in a contained environment, are cost-efficient measures for immediate reduction of Hg emissions.

Liquid discharges from the purifying section display very high mercury concentrations, >1000 mg Hg/kg in sediments and 14 mg Hg /kg in water. The discharge stream and subsequent sedimentation ponds are now completely unsecured. The discharge requires adequate piping, lining and fencing to avoid seepage into ground and surface water, dispersion of sediments and to prevent access for humans and livestock.

Tasks mentioned so far concern issues that need to be addressed for the time the smelter remains operational. Environmental management and safeguard of the slag deposits and the tailings is priority. Further work at the site will need to investigate how these sites can be secured from erosion and seepage of contaminated mine water into the surroundings. It will be the key task at this site to establish technically and environmentally safe conditions possibly with help of covers, bottom lining, re-vegetation and reshaping, etc.

7 Development of Khaidarkan: current activities and future beyond mercury

7.1 Recent developments

Over the past year, a number of developments have taken place in Khaidarkan that potentially influence the future of the operation. Partly unconfirmed information regarding the mine will be presented in this section with reservations regarding data accuracy.

7.1.1 Development plans for Khaidarkan mine

In the light of ongoing technical and economic difficulties described above, there have been several proposals for sustaining mercury production in Khaidarkan. The overall goal is to stabilize mercury production at around 300 tonnes per year and to gradually repay existing liabilities. In order to improve the company results, complex ore mining and subsequent fluor spar production will be suspended due to its inefficiency and priority will be given to mercury production by expanding existing shafts and developing new shafts at significant cost. It is suggested that these measures should enable the company to operate for 4 to 5 years more. In addition to mercury production from mined ore, there are plans to increase the use of secondary sources such as waste materials from abroad or available on site. Since energy cost make up a considerable part of expenditures, energy saving measures are given priority. In addition it is hoped that the government will engage in the operations by providing long-term low interest loans and subsidies for geological exploration.

7.1.2 Investment plan for South Kyrgyzstan

Starting in early 2007, Kyrgyz representatives have established a dialogue with representatives of the city of Vienna, Austria, regarding joint development opportunities. In response to the Kyrgyz request, the Austrian company Alaris AG has developed a Master Plan for South Kyrgyzstan cooperation with the Kyrgyz Ministry of Economic development focussing on Osh, Batken and Jalal-Abad provinces. The Master Plan identifies concrete economic, technical and social infrastructure development opportunities in the region.

In parallel, it was decided to create a public-private-partnership for a joint venture company responsible for developing suitable projects that can be tendered. The Kyrgyz Government has indicated its willingness to make financial contributions to support this project. In November 2008, the Government signed an MoU with the company to pursue cooperation. In Austria the project is coordinated by the Kyrgyz Embassy in Vienna.

Development opportunities described in the Master Plan relevant to Khaidarkan are listed in respective sections in the following chapter.

7.1.3 Global financial crisis

Due to the global financial crisis as well as technical difficulties it appears that Khaidarkan has problems generating sufficient cash-flow to cover operational costs. Reportedly, wages have not been paid to plant workers since November 2008. According to the information available this was still the situation at the time of the submission of this report. It cannot be estimated when the situation will change as the cash flow strongly depends on the mercury sale. This in turn will depend on demand and economic activity at the export destinations.

7.1.4 Ore depletion and alternative sources

On the technical level, as has been stated earlier in this report, the biggest concern is the depletion of mercury ore. Since the independence of Kyrgyzstan, no exploration work has been conducted to identify new mining areas. Until today data created during Soviet times has been used for ore extraction. Even though geologists know about the existence of large cinnabar deposits, further exploration work is required to make them available. As the mine has conducted selective ore mining over the past years to increase efficiency, this means they only chose to mine the areas that were identified as having a high mercury content and leaving behind the lesser ones, only low value reserves remain available.

According to the Master Plan, it will require an investment of about US\$100 million to maintain production at 300-500 Hg tonnes per year if operations are based on ore mining. Furthermore it mentions that construction of 200 km railway will be crucial to support local infrastructure.

Recycling and mercury production from secondary sources such as chlor-alkali sludge is seen as a viable alternative to primary mercury mining. In 2007, the company imported chlor-alkali waste from Irkutsk in Russia which was widely regarded as a successful model for replacing mercury ore mining. However, according to local sources contacted recently much of the Russian waste suitable for re-processing is transported to China. The distant location and the complicated import and export requirements on its way to the Khaidarkan mine render Chinese plants more competitive.

7.1.5 Plant ownership

Recently there have been disputes about the plant ownership with date back to the early 1990 when Kyrgyzstan purchased natural gas from Uzbekistan on credit. The credit has been taken over by Kazakstan who is now requesting to Kyrgyzstan to meet it's obligations of USD 5 million. Since part of the natural gas was used in Khaidarkan, its assets are now claimed by the Kazakh authorities. At the time of publishing this report, the court case was still ongoing.

7.2 Economic alternatives in Khaidarkan

Today, the mine remains state-owned according to official sources and reports to the Ministry of Industry, Energy and Fuel resources and the Prime Minister of the Kyrgyz Republic. According to the Ministry, the Khaidarkan mercury plant is still on the Kyrgyz government's list for privatization for 2008-10. Because a reduction in primary mercury production is also considered imminent by the mine's management, as stated in the Khaidarkan Business Plant for Cement Production (2005), a joint approach needs to be developed to secure livelihoods and human health in the region.

7.2.1 Gold mining

Gold mining plays a very important role in the Kyrgyz economy, with about 1 per cent of the world's gold reserves located in the country (mostly in Naryn, Jalalabad and Issykul provinces). The main gold deposit in Batken province is Altyn Jylga where several small deposits are located. Despite the good knowledge of existing deposits, various local experts ruled out large scale gold mining as an alternative for economic income in Khaidarkan for a number of reasons. In general, gold reserves in the area are considered too remote, small and dispersed to make a large scale mining facility economically viable. According to the Masterplan, developing the Altyn-Jyglja gold deposit would require about US\$100 million.

On the other hand, medium and small scale gold mining is considered be feasible if required technology and infrastructure can be provided. This would comprise investments in ore processing facilities and transportation routes for example. Currently a number of exploration companies are investigating options at numerous refractory gold deposits in Southern Kyrgyzstan that have not been of interest earlier due to the complex extraction required of this type of gold. With change of technology, there is a growing interest in their exploitation. Existing facilities in Khaidarkan (crusher, rotary kiln, tailings pond) could be refitted and used for gold extraction to produce gold concentrate. Thereby Khaidarkan could become a regional hub for these numerous deposits which are too small themselves to install such a facility independently.

In addition, since the the population in Khaidarkan is specialised in mining, their workforce could be applied at such mines. The cost for transport form the Chinese border of Southern Kyrgyzstan to Khaidarkan has been estimated USD 40 per tonne of gold ore by truck. This is still competitive with other facilities in the region, such as China and Kazakhstan given that royalties for the plant remain correspondingly low.

Whether such a regional gold concentration plant would be economically and technically feasible remains to be assessed,

7.2.2 Fluorite mining

As described earlier, Khaidarkan also produces fluorite concentrate extracted from complex ore. Fluorite is commonly used in steel and aluminium production in the area. The production in Khaidarkan has always been subsidised by the mercury sales as the product was non-profitable according to the mine management. Fluorite production has recently been suspended due to the economic difficulties.

However, according to other sources, fluorite could be produced in a profitable way in Khaidarkan if better markets and distribution pathways can be identified. Since the mine management has not conducted any marketing studies or similar but relied on established customers, it is assumed that prices at which Khaidarkan sold its fluorite are far below market value.

In addition, efficiency could be increased with investments in better technologies and exploration of deposits. A great advantage of this option is that current structures could be used and existing workforce could be applied. Whether existing infrastructure can support the profitable production of this product remains to be assessed.

7.2.3 Fire resistant bricks

The area is rich in aluminium oxide and silicon dioxide as has been described earlier. These minerals are also the main components of refractory bricks that form a heat and fire resistant material commonly used in applications with extreme mechanical, chemical, or thermal stresses, such as the inside of a wood-fired kiln or a furnace.

At Ulug-Too, one of the mercury mining sites previously associated with Khaidarkan, a privately owned factory for refractory bricks was built a couple of years ago. Other deposits of suitable material are known in the Khaidarkan area. This option for economic diversification has also been considered by the Khaidarkan management in the past but never been pursued in more detail.

At the moment there is no information on exploration costs or potential markets for such a product but should be retrieved in the course of the economic

7.2.4 Construction industry

As described in the previous section, the construction industry has experienced remarkable growth in region over the past years. Even though many projects have been conducted, there is a big deficit in local capacity for construction. In particular in the area of public works and civil engineering there is hardly any expertise and manpower available. There are only a few construction companies on the local market, mostly based in Osh.

Both private as well as public sector are potential partners for developing this alternative. Should economic development in Batken province be pursued in the future, improvement of infrastructure such as roads, railway and power plants will be essential to achieve this goal.

For the implementation of these tasks increased local capacity in construction and engineering will be required.

In addition to setting up a development programme for the region, one option for achieving this goal would be to create partnerships with an established international construction company interested in cooperation with Kyrgyzstan so that local structures can be improved and technology transfer encouraged.

7.2.5 Bauxite mining and aluminium production

Several bauxite and aluminum plants exist in the region; the most recent one will be constructed in Batken. Bauxite deposits are located in the vicinity of Khaidarkan and repeatedly mentioned as an option for regional development.

Experts from the Kyrgyz Mining Association described bauxite ores occurring in the area as suboptimal for large scale aluminum production due their high content in silica oxide and existing deposits as limited.

Also, it was concluded that environmental impacts from aluminum production can be regarded as comparable to those created by mercury production as practiced today. A new alumina plant in the Ferghana Valley would risk opposition from neighboring countries and lead to a difficult authorization process. Aluminum production is a highly energy-intensive process and its demands would be very difficult to meet given the country's difficult energy-security situation.

The Masterplan envisages capital investment up to US\$3 thousand million for an alumina plant with 250 000 tonnes output a year, employing about 7 000 people. Russia and China are indicated as potential clients.

As an alternative to this capital intensive and technically challenging option, the Kyrgyz Mining Association proposed to focus on economically more feasible small to medium scale bauxite mining. Mine ores could be sold to an aluminum plant in neighboring Tajikistan rather than producing aluminum in Kyrgyzstan proper. Experts from the Kyrgyz Mining Association presume that the planned aluminum plant in Batken will not use locally mined ores but import higher quality ores from Ukraine, Russia or elsewhere.

7.2.6 Bentonite

According to the Ministry of Geology and the Kyrgyz Mining Association there are substantial reserves of bentonite/montmorillonite in the Khaidarkan area which can be exploited with relatively little effort as the deposits are close to the surface.

Bentonite is an absorbent aluminium phyllosilicate, generally impure clay consisting mostly of montmorillonite. It is a useful adsorbent of ions in solution as well as fats and oils and expands when wet, possibly absorbing several times its dry mass. Bentonite is used in more than 200 products, from paint and textiles to soap, adhesives, beverages, and cosmetics. It

is also mixed with water to form a mud that lubricates and optimizes drilling in oil and gas exploration. Other products and uses of bentonite are:

- environmental remediation of landfills
- cement, adhesives, ceramic bodies
- therapeutic face pack for the treatment of acne/oily skin
- winemaking, to remove excessive amounts of protein from white wines
- paper making

Other bentonite mines in Central Asia are located in the Navoy province in neighbouring Uzbekistan which are successfully exploited by a Swiss-Uzbek private enterprise. There is high confidence that there will be a satisfying market for bentonite produced in Khaidarkan since there are numerous uses for the product such as oil and gas exploration, a frequently conducted activity in Central Asia, with only limited bentonite supply from the region.

Bentonite from the area can also be used for the remediation and land reclamation works at the mercury mining site. The presence of required construction materials constitutes a great advantage for cost and feasibility of the environmental remediation works that should be considered in Khaidarkan. The Kyrgyz Mining Association estimates the required investment for exploration and pilot plant US\$10 million.

7.2.7 Cement production

The Khaidarkan mine has increasingly recognized the growing technical constraints it is facing from ore depletion and water intrusion. In 2005 the company prepared a business plan for a cement plant in Khaidarkan based on local availability of skilled human resources and existing equipment in order to sustain economic activity by diversifying local business operations. Cement production has been identified as a suitable opportunity with a similar profile to the existing plant. The business plan states that the cement plant will use mercury production waste which will reduce the environmental burden at the site and 'create major positive local environmental effects'.

The planned capacity of the plant is 600 000 tonnes of cement per year with an input of 1 million tonnes of feedstock consisting of 50 per cent mercury slag. Other proposed components are limestone, dolomite, pyrite slag, calcium chloride and gypsum which partly need to be imported. According to the business plan, the technical characteristics would allow to process mercury production waste with a high degree of metal extraction and good technical characteristics, yielding a product suitable for hydraulic and civil engineering. The required investment is estimated as US\$29 million at a production cost of US\$21.5 per tonne of cement²⁰. At these dimensions, the plant would employ around 100 people.

²⁰ For a gas price at US\$0.062/m³ and electricity price at US\$0.011/kWh

During tests aimed at identifying mercury compounds in the cement production process, the following concentrations of mercury compounds were found:

Clinker:	not detected
Dust:	1.4 – 2.0 per cent
Exhaust gases:	1.2 – 3.6 per cent

Cement production is planned to apply energy-saving technologies. To reduce emissions, process gases containing dust particles and metals will be cooled and directed into filters and re-processed. Mercury will be captured by foam filters. The business plan estimates that about 19.5 tonnes of mercury a year will be extracted during the cement production process.

Table 14 **Calculated annual economic benefits of cement production**

	in US\$ million
Total income	21.9
Total production expenditures	18.1
Cement production	17.9
Mercury extraction	0.17
Income (before taxes)	3.8
Net income (after taxes)	3.1
Period of repayment of capital investments	10 years

According to experts from the Kyrgyz Mining Association and the Ministry of Geology, the economic viability of the potential project is likely to be constrained by two new cement plants in South Kyrgyzstan, Arawan next to Osh (200 000 t/year) and Kyzyl-Kya (1 million t/year) to be completed in 2009. Even though South Kyrgyzstan has displayed growing demand for building materials in the past, it is considered unlikely that an additional 600 000 tonnes of cement a year will find a market. Moreover, the remote location of Khaidarkan and the unfavorable infrastructure hamper distribution of the product and reduce the plant's competitiveness.

Other than for building materials, cement produced at Khaidarkan can also be used for land reclamation purposed by joining cement and slag as backfilling for the underground mines. The benefits of such an intervention remain to be assessed but should definitely be considered in the remediation process.

7.2.8 Mercury recycling

Recycling of mercury-rich wastes, in particular waste materials originating from chlor-alkali production facilities can be considered as a transition away from primary mercury production. Secondary mercury production also appears to be more convenient and efficient considering ongoing technical problems at the site such as ore depletion and water pumping.

As described earlier, about 200 tonnes of chlor-alkali waste were processed in Khaidarkan in 2008 without official registration. The treatment has been described as economically successful and the company expressed its interest in continuing this practice. However, it

appears that complicated or unclear legal requirements for importing and handling the waste material create constraints in continuing and officialising the practice. Support for the company in addressing these issues might catalyze further activities that replace virgin mercury production.

Should such practice be pursued in the future, it is indispensable to enhance smelter and waste disposal facilities should environmentally responsible conditions be attained in Khaidarkan. As described earlier, rotary kiln seal, condenser performance and waste water management need to be significantly improved before any further, primary or secondary, mercury production can be considered at the site.

This option is considered undesirable as the related cost to make mercury recycling environmentally safe at the site is technically very difficult and the associated cost will probably exceed the economic benefits by far. Implementation of environmental protection measures would then be very unlikely.

7.2.9 Others

The former industrial town Kyzyl-Kya has seen significant development in past years and is expected to reclaim its position as the industrial centre of the province and southern Kyrgyzstan. Among the new developments, as mentioned, is a cement plant planned as Chinese-Kazakh-Kyrgyz joint venture with capacity of 1 million tonnes per year. It will be completed and start operation in 2009. This plant will consume almost 100 000 tonnes of coal – as its main source of energy – and will reportedly apply the latest environmental safety technologies, including zero-emissions policy. However, the EIA for this plant has not been prepared yet.

The plant is expected to employ over 100 people, with a distance of 75 km to Khaidarkan, it might create an alternative source of income for many who are willing to commute week by week or to move their households to Kyzyl-Kya.

In 2008, the Kyrgyz Ministry of Finance listed a number of investment possibilities for Batken province. Tourism attractions include peak Piramidalny, peak Asan-Uson, base-camp Dugoba. Juniper forests and hiking/horse paths are frequented by local and international visitors and development of the community-based tourism has good prospects, given that infrastructure and accessibility is improved. Batken province is famous for apricots (production potential 12 000 tonnes a year) and other fruits and vegetables (cherry, apples, pears, grapes, pomegranates) in total 35 000 tonnes, which provides excellent conditions for manufacturing of dry foodstuff. The Ministry of Industry also indicated production of local foodstuff specialities such as dried apricots as promising development option for rural areas.

The Batken Province Masterplan specifies investment opportunities in the food sector of Batken province which vary from US\$1 to 100 million in investment volume.

8 Action Plan recommendations

Since independence, as economic pressures have mounted at Khaidarkan, less resources have been available for pollution prevention. There is a backlog of mitigation necessary to bring the industry up to international standards or in case of closure to rehabilitate mined-out areas for which the Kyrgyz Government has limited resources. In addition, even though the calibre and technical training of Kyrgyz environmental and health and safety specialists is excellent, they have not been sufficiently exposed to or are not experienced with current internationally accepted concepts of proactive environmental management practices and mine closure. The study has identified the following key area for future development:

- Better control of mercury emissions from point and dispersed sources at the active Khaidarkan plant, especially smelter rotary kilns, condensers and the central stack. This action, if fully implemented, could drastically reduce industry's mercury emissions.
- Update emission (instrumental measurement-based) inventory for mercury and other hazardous substances originating from Khaidarkan plant operation and revise emission permit criteria.
- Improve reporting quality and requirements with regard to mercury emissions into the atmospheric air, waste disposal, mercury concentrations and associated health impacts of mercury pollution.
- Strengthen monitoring and enforcement of mercury emissions and concentrations requirements.
- Plan socially-responsible mine closure and develop environmentally acceptable and economically affordable safety and rehabilitation methods for mercury-containing waste (sludge, slag and tailings) and mercury-contaminated land (smelter site, polluted agricultural soils).
- Develop potential for viable alternative economic activities and sustaining livelihoods in the area to replace primary mercury mining
- Improve public awareness in the present and former mercury production areas of Kyrgyzstan and citizens' right to know. These measures should aim to reduce unnecessary exposure of local population (due to cattle-grazing, water consumption, waste material re-use) to the acute environmental hazards related to waste sites and streams.
- Establish a monitoring system on environmental impacts near the tailings to identify practical measures for reducing harmful effects on the health of people living in surrounding areas.
- Introduce monitoring of the shaft water which is used to irrigate farmlands
- Tailing facilities should be equipped with technical means of communication and alarm systems, ensuring control of technological processes, control and safety

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ANNEX I

Situation at the abandoned mercury mines, formerly under Khaidarkan mine complex management: Chonkoy-Ulug-Too and Chauvay

Chonkoy-Ulug-Too

The Chonkoy-Ulug-Too²¹ mine (coordinates 40 22N, 72 26E; elevation 1 250 to 1 350 m; average air temperature in January -4°C, in July +23°C; annual rainfall 200-400 mm; average wind speed 2m/s) lies 10-15 km northeast of Nayman (1 800 people), once a town of mine workers. Administratively, the site is located in the Nookat district of Osh province and is on a list of investment projects. The Chonkoy deposit contains mercury reserves defined by category²² C-1 at 6 000 tonnes and category C-2 at 18 000 tonnes, with average Hg content of 0.25 per cent. The mine, which belonged to the Khaidarkan plant, was exploited from 1963 to 1994 by underground methods and employed 600-700 people, mostly of Nayman and Kyzyk-Kya towns. The number of population of Nayman in the peak production period was 3.5 thousand (with 90 per cent Russian majority). It closed in September 1995 due to lack of state subsidies, skilled labor migration and complex market situation. In 1998 the remaining mine assets were transferred to private ownership and the smelter was active again for a few months to process mercury-rich waste. Then smelting activities stopped completely. Much of the property has since been looted.

The former infrastructure of the Ulug-Too mine comprises electricity and water lines (still operational), underground mine, an ore enrichment section, a metallurgy plant, tailing and slag disposal sites, in other words a complete mercury production cycle. The mine shaft depth reaches 980 m below surface; shaft is characterized by unstable geological rocks with burst-prone layers. Deposits containing mercury ore, ranging from 5 000 to 70 000 cu m in size, are located in the shale-limestone thrusts at depths 600 to 1 000 metres, inclined 35° to 90°. Due to groundwater intrusion, the water was pumped out for 2-3 hours a day. The ore was delivered on the surface by trolleys with capacity of 2.8 tonnes each. The former production capacity of the mine was 450-500 tonnes of ore a day, with mercury production of 150 tonnes a year (in 1990).

Apparently, the site was abandoned without any environmental remediation. Limited information about its former environmental performance is available in the Ecological passport of Khaidarkan (1990). Energy consumption by the mine was estimated at 15 million kWh, water consumption at 2 million m³. Atmospheric mercury releases from the smelter were 2.2 tonnes per year; from other sources 0.8 tonnes. Currently, the slag waste occupies approximately 10 ha (with height up to 15-20 m in places; estimated amount 2 million tonnes) and the tailings 4 ha. The ore enrichment section and mercury smelter have been fully dismantled, only concrete and bulk metal structures remain on site. Mercury concentrations in the slag waste surface layer (20-30 cm) are estimated at 26-28 ppm, while concentrations in the tailing and pipe sections are 120-720 ppm. The slag and tailing are not

²¹ Chonkoy refers to the geological name of the ore deposit and Ulug-Too refers to the mine, smelter and adjacent mountains

²² Category C1 refers to the established reserves and C2 to the inferred reserves

equipped with fences or warning signs, so local people and farm animals can access the site. Farming is limited to small patches of land; agricultural soils (2.5 km away) do not exhibit high level of mercury. The site was visited by UNEP/GRID-Arendal team in July and October 2008. No surface water streams are present in the area except pipe water (50 l/sec, supplied from Obshir River).

Chauvay

The Chauvay mining site (coordinates 40 07N, 72 12 E, elevations 1 690 to 2 100 m) is located 30 km southeast of Kyzyl-Kya, near Chauvay (1 600 people), once a town of mine workers. The population has dropped here by 500 people since the mine closed. Administratively speaking, the site is part of the Kadamjai district of Batken province. The mine was linked to the Khaidarkan mercury plant and active from 1942 to 1993. Available data on mercury reserves in the Chauvay deposit indicate 800-1000 tonnes of metal with an average mercury concentration of 0.3 per cent. Only limited technical data is available for the Chauvay mining site.

The Ecological passport of the Khaidarkan (1990) reports that atmospheric mercury emissions were estimated at 1.1 tonnes; ore extraction 50 thousand tonnes; mercury production 50 tonnes a year (in 1990). Water use - 350 thousand m³, mostly from the Chauvay river (discharge 250 l/sec in summer, 25 l/sec in winter); wastewater discharge from the smelter - 150 m³ per day (after primary treatment in the sedimentation tank) directly into the river.

The field assessment and limited environmental sampling around the Chauvay mine conducted by the UNEP/GRID-Arendal team in July 2008 produced the following information: the former smelter and what are presumably slag and tailing waste are in a dangerous position in the flood-prone river valley and along its banks. They are also subject to water and wind erosion. Scattered waste in the amount of 1 million tonnes occupies an area of 8 ha (sometimes with hips 15 m high), with no fence, warning or identification signs. Mercury (Hg) concentrations of unidentified tailing-like waste dumps near the river bed range from 270 to 550 ppm, antimony (Sb) concentrations from 5 100 to 5 500 ppm, cadmium (Cd) from nil to 4 ppm, selenium (Se) from 2 to 18 ppm. The water in the river 2 km downstream has a normal mercury concentration (but no samples of river sediments were taken). However antimony concentrations are high (0.196 mg/l). The Chauvay community uses water from the river for drinking and irrigation. Crop growing is restricted to small plots of land and gardens along the riverside. Water availability in the river is limited (the river bed is almost dry).

The Ministry of emergencies maintains basic records of waste at the abandoned mines; however it is not tasked with monitoring safety conditions or implementing remediation.

The main issues at the former Hg mining sites are the large amounts of uncontained slag and other waste eroding into the environment, the lack of warning and identification signs, and environment and health risks, particularly in the Chauvay. The local environmental authorities and public organizations (Osh Aarhus centre) are concerned with the environmental situation on the abandoned mercury sites and are appealing for further assistance.

ANNEX II

Mercury levels in the environment: international values and the Kyrgyz regulations

Background mercury levels

Air

Background mercury levels in the troposphere of the northern hemisphere are estimated at 2 ng/m³. In areas of Europe remote from industrial activity, such as rural parts of southern Sweden and Italy, mean concentrations of total mercury in the atmosphere are reported to be in the range 2-3 ng/m³ in summer and 3-4 ng/m³ in winter. Mean mercury concentrations in urban air are usually higher (10 ng/m³). The exposure to mercury from outdoor air at these levels is not expected to have direct effects on human health. "Hot spots" of mercury concentrations have been reported in the atmosphere close to emission sources. For example in Japan, air concentrations up to 10 000 ng/m³ were reported near rice fields where mercury fungicides had been used and values of up to 18 000 ng/m³ near a busy motorway.

Drinking-water

Mercury in drinking water is usually in the range 5-100 ng/litre; average 25 ng/litre. The forms of mercury in drinking-water are not well studied; Hg⁺⁺ is probably the predominant (WHO 2005).

Foodstuff

Concentrations of mercury in most foodstuffs are often below the detection limit (usually 20 ng/g fresh weight). Fish and marine mammals are the dominant sources, mainly in the form of methyl-mercury compounds (70 per cent to 90 per cent of the total). Mercury concentrations in tissues of various species of fish cover a wide range from 50 to 1400 ng/g fresh weight depending on factors such as pH, the redox potential of the water and the species, age and size of the fish. Large predatory fish, such as pike, trout and tuna, as well as seals and toothed whales contain the highest mercury concentrations (WHO 2000).

WHO Guidelines

The estimated guideline value for mercury concentration in the air is 1 µg/m³. The table below shows concentrations of mercury in air and urine at which effects are observed in workers subjected to long-term exposure to mercury vapour.

Observed effect	Mercury level	
	Air µg/m ³	Urine µg/l
Objective tremor	30	100
Renal tubular effects	15	30
Non-specific symptoms	10-30	25-100

The guideline value for total mercury (organic and inorganic) in drinking-water is 0.001 mg/l and 0.006 mg/l for inorganic mercury only (WHO 2005).

The Food and Agriculture Organisation (FAO) and WHO set provisional maximum weekly intake level for mercury at 1.6 µg/kg body weight, which could be consumed over a lifetime without appreciable health risk (WHO 2000).

Regulations on mercury limit values in the environment in the former USSR, Russia and Kyrgyzstan

No firm and latest data is available on mercury concentration regulations from the Kyrgyz authorities so far. Since no new regulations for mercury concentrations in the environment were introduced in the Kyrgyz Republic after independence, it is assumed that the main regulatory documents developed and adopted by the environment and health authorities of the former USSR reflect to a certain extent the transposition of these regulations in the Kyrgyz Republic. The content of mercury in different media is regulated by maximum allowed concentrations (MAC). The REHRA project has provided the following information:

Kyrgyz legislation limits on selected contaminants in surface water and soil

Substance	Surface water, mg/l	Soil, mg/kg
Mercury	0.0005	2.1
Antimony	0.05	4.5
Lead	0.03	6
Arsenic	0.05	2
Cadmium	0.001	1
Ion fluoride	1.5 (0.7 drinking water)	10

MAC of mercury and its compounds in the atmospheric air of the inhabited localities

Substance	Maximum, mg/m ³	Average daily, mg/m ³
Metallic Mercury	-	0.0003
Diethyl Mercury	0.0003	-
Mercury ²³ dinitrate	-	0.0003
Mercury nitrate	-	0.0003
Mercury chloride	-	0.0003

²³ Values are presented in conversion to mercury

Maximum allowable residues (MAR) of mercury in foodstuff

Foodstuff	Mercury, mg/kg
Fish	0.5
Meat	0.03
Milk products	0.005
Vegetables	0.02
Bread and cereals	0.01
Fruits	0.01
Juices	0.05

ANNEX III

Air pollution measurements, Eco-passport 1990

Air temp (°C)	Wind direction	Wind speed (m/s)	Hg, concentration (mg/m ³)	Limit (number of times exceeded)
Air pollution in and around Khaidarkan (hotel)				
24	E	4	0,0042**	14,0
22	Still	0	0,0004*	1,3
21	NW	2	0,0005*	1,7
20	E	3	0,0011*	3,7
20	E	3	0,0011*	3,6
19	NW	2	0,0009*	3,0
15	E	4	0,0023*	7,9
13	Still	0	0,0005*	1,7
9	Still	0	0,0006*	2,0
6	Still	0	0,0004*	1,3
4	E	4	0,0016*	5,5
4	SW	4	0,0004*	1,2
3	Still	0	0,0005*	1,7
1	Still	0	0,0006*	2,0
0	W	3	0,0003	1,0
-1	E	3	0,0015*	5,0
Air pollution in and around Khaidarkan (Vostochnaya shaft)				
25	W	3	0,0012*	4,0
15	NW	3	0,0010*	3,5
12	W	5	0,0003*	1
13	SW	4	0,0008*	2,9
8	Still	0	0,0006*	2,0
0	NW	3	0,0006*	2,0

*exceeding Kyrgyz limits by a factor <10

**exceeding Kyrgyz limits by a factor >10

Waste analysis, UNEP/GRID –Arendal 2008

Sampling site	Cd (mg/kg)	Hg (mg/kg)	Pb (mg/kg)	Sb (mg/kg)	Se (mg/kg)
Khaidarkan					
Rotary kiln slag	4.9	203.3	68.1	1516.9	9.3
Rotary kiln slag	7	228	31	2023	7
Rotary kiln slag	3	199	41	2784	3
Metallurgic sludge, dry	27.1	>1000	107.6	8768.7	47.8
Metallurgic sludge, waste-stream sediment	11.4	>1000	72.1	4316.3	130.6
Tailings	5	126	251	640	<1.5
Sediments, sewage stream	11.8	>1000	44.6	6828.7	42
Sediments, shaft water	0.8	158.7	18.2	251.4	5.9
Sediments in the process discharge stream	9	>1000	49	2759	45
Ulug-Too					
Evaporator waste	<0.25	729	13	10	14
Metallurgic slag	<0.25	26	<3.5	<2.5	8
Tailings	5	126	251	640	<1.5
Slag deposit	<0.25	28	10	7	<1.5
Reference soil	1	1	24	3	<1.5

Liquid discharges, UNEP/GRID Arendal 2008

Location	Cd (mg/l)	Hg (mg/l)	Pb (mg/l)	Sb (mg/l)	Se (mg/l)
Khaidarkan					
Tailings effluent, 500 m downstream dam	<.0020	<0.0005	<0.02	<0.02	<0.02
Shaft water	<.0020	<0.0005	<0.02	<0.02	<0.02
Tailings Drainage	<.0020	<0.0005	<0.02	<0.02	<0.02
Overflow from metalurgic sludge sedimentation	0.007	14.0	<0.02	5.68	0.100
Metallurgic sludge, waste-stream	<0.002	1.53	<0.02	0.759	<0.02

Air emissions of Khaidarkan in 1990

Industrial site	Temporarily agreed Hg emissions and actual emissions in 1990 (tonnes)	Maximum permissible Hg emissions to be ensured by 1995 (tonnes)
Khaidarkan (central pipe)	0,17	0,017
Khaidarkan (rotary kilns)	14,4	1,12
Khaidarkan (other)	5,0 including 3,7 slag waste/load	4
Ulug-Too (rotary kilns)	2,2	0,3
Ulug-Too (other, slag)	0,8	-
Chauvay	1,1 (0,7 smelter + 0,4 slag)	-
TOTAL		
Khaidarkan	15,4	
Ulug-Too	3,1	
Chauvay	1,14	

Source: Khaidarkan Ecological Passport, Ministry of Ministry of Metallurgy of the USSR, 1990

Waste generation and analysis, Eco-passport 1990

Source	Area (ha)	Volume (m3)	Hg content (mg/kg)	Density (t/m3)
Khaidarkan, slag	32,3	8170000	1-50	1,73
Khaidarkan, tailing	27,8	2808000	20	1,4
Khaidarkan, sludge	0,5	-	-	-

Source: Khaidarkan Ecological Passport, Ministry of Ministry of Metallurgy of the USSR, 1990

Water consumption, Eco-passport 1990

Industrial site	Water consumption (m3 per year)
Khaidarkan, Gayuan river	4472000
Khaidarkan, ground	308000
Khaidarkan, shaft water	828000
Ulug-Too, all sources	2113000
<i>Ulug-Too, shaft water</i>	10000
Chauvay, Chauvay river	362000
Chauvay, shaft water	80500

Water analysis, UNEP/GRID Arendal 2008

Location	Cd (mg/l)	Hg (mg/l)	Pb (mg/l)	Sb (mg/l)	Se (mg/l)
Khaidarkan					
Tap water, city hotel	<0.002	<0.0005	<0.02	<0.02	<0.02
Gauyan river, bridge, near to UZB border, 8 km west	<0.002	<0.0005	<0.02	0.059	<0.02
River Gauian, drinking water intake for Khaidarakan	<.0020	<0.0005	<0.02	<0.02	<0.02
River 300 metre downstream mine	<.0020	<0.0005	<0.02	0.032	<0.02
River water in irrigation channel after tailings	<.0020	<0.0005	<0.02	0.028	<0.02
Chauvay					
River (2 km down the mine site)	<.0020	<0.0005	<0.02	0.196	<0.02
Reference	<.0020	<0.0005	<0.02	<0.02	<0.02

ANNEX IV

Selected photographs



Figure 10 Welcome poster: west entry into Khaidarkan



Figure 11 Khaidarkan in 1941

http://www.khaidarkan.narod.ru/Peyzazhy/panorama/pan_gl.htm



Figure 12 Mining cinnabar at Khaidarkan: 400 metres below surface



Figure 13 Khaidarkan mine: Vspomogatelnaya shaft (400 m). Carstic water intrusion



Figure 14 Discharge of the shaft water on surface



Figure 15 **Khaidarkan mine: Carstic water intrusion. July 2008**



Figure 16 **Wastewater stream from the Khaidarkan metallurgic plant**



Figure 17 Wastewater sedimentation tank and sludge from the metallurgic plant



Figure 18 Slag from the metallurgic plant



Figure 19 Mercury smelter stack



Figure 20 Rotary kilns and condensers



Figure 21 Natural gas burner



Figure 22 Condenser section



Figure 23 **Ore enrichment section**



Figure 24 **Tailings pond**



Figure 25 **Gauyan River upstream. October 2008**



Figure 26 **Gauyan River downstream. October 2008**



Figure 27 Chonkoy-Ulug-Too mine: metallurgic slag



Figure 28 Chonkoy-Ulug-Too mine: dry tailings and wastepipe



Figure 29 Chonkoy-Ulug-Too mine: remains of rotary kilns and smelter. July 2008



Figure 30 Chonkoy-Ulug-Too mine: Dismantled ore milling section. July 2008



Figure 31 **Chauvay mine: Dismantled rotary kilns and smelter. July 2008**



Figure 32 **Chauvay mine: Slag waste. July 2008**



Figure 33 UNEP/GRID-Arendal team and field mission to Khaidarkan. July 2008



Figure 34 UNITAR and UNEP/GRID-Arendal field mission to Khaidarkan. October 2008



Figure 35 Shaft water sediments sampling



Figure 36 Vegetable samples collection