Khaidarkan alternatives

Towards a mercury-free future

Ken-Too Project Design and Research Centre

Kyrgyz Mining Association

Zoï Environment Network

Khaidarkan Alternatives

Towards a Mercury-Free Future

Feasibility Study

Development of gold and other mineral deposits near Khaidarkan

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EXECUTIVE SUMMARY

The world's governments agreed at the United Nations Environment Programme (UNEP) Governing Council in 2009 to prepare a legally binding instrument on mercury to protect human health and the environment from mercury-related risks. After the shutdown of major mercury deposits in Almaden (Spain), Idrija (Slovenia) and Algeria, the Khaidarkan mine in southern Kyrgyzstan is the last remaining major supplier of primary mined mercury to the international marketplace. International efforts are underway to reduce mercury use and emissions and phase out primary mercury mining throughout the world.

This study explores selected options that can replace the mercury mining at the Khaidarkan Mercury Combine (KMC) near the Aidarken settlement in Kyrgyzstan. It considers mining economics, geology and the environmental, health and social effects of the various alternatives.

KMC belongs to Khaidarkan Mercury Joint Stock Company (KMJSC) and 99% of KMJSC shares are controlled by the state. KMJSC sees its future in the development of its lower-level mineral deposits. These complex reserves comprise in excess of 3.5 million tonnes of ore containing fluorspar and cinnabar, from which mercury is extracted. The Khaidarkan Mercury Combine continues to mine primary mercury at the rate of 100–150 tonnes per year. The state support of the industry includes subsidies for geological exploration and favourable electricity tariffs that lower the cost of pumping water from mines.

This study examines the feasibility of phasing out KMC mercury production by exploring the development options of non-metallic mineral deposits and gold deposits in the proximity of the Aidarken. The specific criteria considered in the analysis of options include: consistency with transformation goals (including social goals); the number of new jobs created; the ecological impact; organizational and technical feasibility; the development stage of a project; economic feasibility; possible utilization of the basic production assets of the Khaidarkan Mercury Plant; local support and employment of the local workforce; national and regional priorities (social, economic and environmental); and compatibility with international development projects.

The results of this study show that the gold deposits and other non-mercury minerals located near Aidarken provide the opportunity not only to replace mercury production cost-effectively, but also to create new jobs. Further discussions, capacity-building for all stakeholders and development of the financial options to change the plant's business profile are necessary in order to achieve further results.

While the proportion of jobs that could be created through organization of non-metallic mineral mining cannot fully replace Khaidarkan's workforce of more than 500 people, this kind of mining activity has fewer environmental impacts and is not necessarily reliant on multinational companies. The skill level required in non-metallic mining is lower than that required for the work at Khaidarkan or other metal (gold) deposits, and local workers could compete with the more highly skilled Khaidarkan workers. The skilled workers have the option of finding jobs in other mining projects throughout the country, but the overall loss of jobs in case of Khaidarkan mine closure may convince the Kyrgyz government that non-metallic mineral mining option alone is not sufficient.

Aluminium production, often cited by officials and the media as a promising option, is a long-term prospect linked to hydropower development and strategic industrial priorities. In light of border sensitivities, the absence of rail infrastructure, limited business interest and the large scale of the project, this option was not considered among the near-term possibilities.

The study considered two options to ensure the development of gold mining and processing – the development of mining and processing operations located in proximity to the deposits, and the development of a cluster gold processing and concentration plant (CGCP) on the basis of KMC. The second option entails the development of capacity in stages – first, the upgrading and conversion of the KMC's mothballed beneficiation plant to be used for gold extraction, and then the construction of new facilities.

According to the technical and economic estimates produced by the Ken-Too mining project design centre and the Kyrgyz Mining Association, the most economically and environmentally viable option is a cluster gold processing and concentration plant in Aidarken. This option converts the existing KMC fluorspar processing plant to a gold concentration plant at an estimated cost of USD 2 million to USD 3 million, and increases plant capacity from 100,000 tonnes to 200,000 tonnes, adding 160 jobs. The construction of a new gold concentration plant with a capacity of 500,000 tonnes per year or more would follow the confirmation of ore reserves at the nearest deposits, and will cost an estimated USD 40-60 million and add another 240 jobs for a total of 400.

The plant will be able to service a number of nearby gold deposits, and about 100 people will be needed to transport ore from the gold deposits to the plant. In addition, some KMC employees may be employed in technical and mining jobs at the neighbouring deposits. The construction of the KMC gold processing and concentration plant is considered to be realistic and efficient, but requires organizational changes and agreements with the owners of the rights to the gold deposits. Geologic exploration would add another USD 20 million to USD 40 million in costs. In addition, occupational and environmental health concerns will necessitate improvements in tailings management, enhanced control of the by-products of gold beneficiation processes.

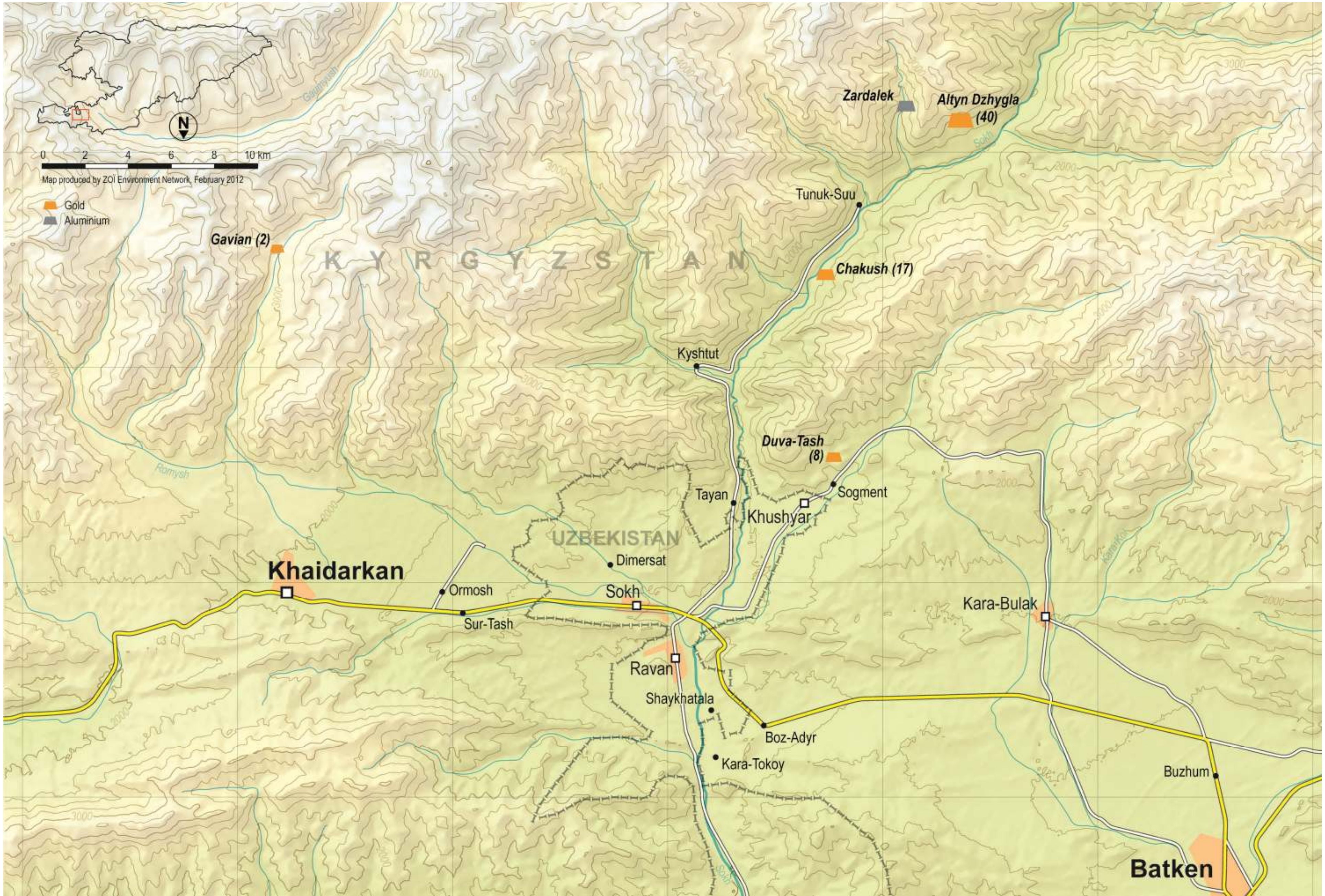
One likely ore source is the Altyn Jygla gold deposit where the reserves are already approved by the State Reserves Committee of the Kyrgyz Republic and have the status of mineable ores. The deposit is ready for operation, but the local population has a negative attitude toward the construction of tailings and processing facilities near the deposit. Surveying and prospecting operations are being conducted at the Aprelskoye deposit and the preparation of a report with detailed reserve estimates is in progress. Geological exploration is currently under way at the Duva-Tash deposit. At the Chakush and Gavian deposits no substantial prospecting work has been carried out since the collapse of the Soviet Union and neither exploration nor mining licenses have been issued.

The varying degrees of development of the deposits implies a gradually increasing production with different starting times for the operations. This schedule enables the preparation of procedures for processing ores of varying mineral and chemical compositions, gold content and process qualities. Simultaneous mining of the nearby gold deposits and processing at the cluster plant in Aidarken can provide 1,500–1,700 new jobs. Indirect and induced employment will add another 1,500 jobs.

Compared to construction of plants with tailings at each deposit, the single KMC gold processing and concentration plant has a number of advantages: lower capital expenditure; lower impact on the environment and mountain ecosystems; a positive perception of the mining sector by the population; less permitting documentation; a shorter lead time for project commencement; and the availability of an existing professional team, infrastructure, production capacities and industrial land. These advantages are complemented by cost savings related to construction engineering, the availability of tailings facilities and the possibility of combining mining and deposit exploration simultaneously.

Batken region has deposits of non-metallic minerals – bentonite, serpentinite, gypsum and facing stones – that could be extracted, processed and sold in local and regional markets. The mining and processing of these minerals could employ up to 50 people. The capital investment needed for each of the options varies from USD 0.5 million to USD 1.0 million.

In view of the current pressures on the national budget, state financing for changing the production profile of the Khaidarkan Mercury Combine is unlikely. Private investors could provide financing, but state ownership of the mercury plant will require respective agreements. Apart from its commercial purpose the project to convert the mercury plant has an environmental objective – the reduction of mercury production and emissions in a socially responsible manner. This objective makes the participation of international donors relevant, and their assistance is needed on organizational matters and for presenting the case to investors and support in technical design.



0 2 4 6 8 10 km
Map produced by ZOI Environment Network, February 2012
Gold
Aluminium
KYRGYZSTAN
UZBEKISTAN
Zardalek
Altyn Dzhygla (40)
Gavian (2)
Chakush (17)
Duva-Tash (8)
Tunuk-Suu
Kyshtut
Tayan
Sogment
Khushyar
Dimersat
Khaidarkan
Ormosh
Sur-Tash
Sokh
Ravan
Shaykhatala
Boz-Adyr
Kara-Tokoy
Kara-Bulak
Buzhum
Batken

Summary of project performance: geological, socio-economic and environmental factors

Deposit or facility	Distance to Aidarken, km	Mineable ores, tonnes Resources, C Reserves, P for gold deposits: (concentration g/t)	Project lifetime, years	Employment needs, persons * for gold deposits: with Khaidarkan without Khaidarkan	Capital expenses, US $ million for gold deposits: with Khaidarkan without Khaidarkan	Operating expenses per tonne of ore, US $ for gold deposits: with Khaidarkan without Khaidarkan	NPV, US $ million for gold deposits: with Khaidarkan without Khaidarkan	IRR, %	Overall pressure on mountain ecosystem, expert estimate for gold deposits: with Khaidarkan without Khaidarkan
Gold: Altyn-Dzhylga	50	3 861 000 (5.4) 4 012 000 (5.3)	9	450 600	57,8 94,6	88.7 70.4	18.1 17.7	24.2 21.1	Medium Elevated
Gold: Chakush	40	2 658 000 (6.4)	14	350 456	46,1 64, 8	77.31 72.42	41.47 33.034	39.2 29.7	Medium Elevated
Gold: Duva-Tash	30	1 721 000 (4.8) 4 900 000 (4.1)	13	200 250	18,3 31,2	72.54 66.23	5.369 0.203	23.1 15.2	Medium Elevated
Gold: Gavian	20	142 200 (10.3)	3	50 50	19,8 31,2	83.46 68.19	1.133 0.203	27.9 19.3	Elevated High (juniper forest zone)
Gold: Aprelskoye	180	1 562 000 (6.4)	12	200 250	49,3 33,2	89.20 70.14	14.689 15.949	29.1 24.3	Medium Elevated
Gold processing plant: upgrade of the existing KMC plant to 200 000 t	0	N/A	15	160 **	2-3	N/A	N/A	N/A	Medium + curbing mercury emissions and primary Hg mining
Gold processing plant: construction of new plant at KMC, 500 000 t	0	N/A	12	240 **	40-60	N/A	N/A	N/A	Medium + curbing mercury emissions and primary Hg mining
Gypsum: Kanskoye	30	> 10 000 000	100	21	1,1	23.53	marginal or negative profit		Low
Bentonite: Kyzyl-Utek	90	> 10 000 000	50	10	0,5	10.96	0.4068 (net profit)		Low
Serpentinite: Kanskoye	30	> 5 000 000	20	21	1,2	8.22	0.995 (net profit)		Low

* all sources of work force (including roughly 30-50% from Khaidarkan)

** 100% from Khaidarkan

INTRODUCTION

Currently, the Kyrgyz Republic is the only country mining mercury ore and producing primary mercury for export to the global market. The total output of primary (ore-based) mercury and secondary mercury (received from waste material) at Khaidarkan Mercury Combine (KMC) is 100 to 150 tonnes per year though in the past, it was 450-600 tonnes per year. The entire volume is exported comprising up to 10% of the volume of global mercury market.

A project to support the Kyrgyz Republic transition away from mercury mining has been on-going since 2008 with project support from UNEP, UNDP, UNITAR, Zoi Environment Network and the Governments of Switzerland, Norway and the U.S. The global move towards a future mercury treaty and the associated future global controls expected for mercury and mercury-containing products use, import, trade and production, are likely to have implications for mercury demand from Khaidarkan. Curbing mercury mining, although desirable from an environmental point of view could compromise the local livelihoods and the existing economic setting. Therefore, a cessation of mercury mining is a delicate issue requiring a balanced socially responsible approach to the interests of all stakeholders.

From the Kyrgyz side the topic is not as simple as abrupt cessation of mercury production would impoverish a large number of families from more than ten thousand people living in Aidarken settlement and would have a negative impact on the local infrastructure, enhance internal and external migration and decrease the budget revenue. Therefore, reduction and termination of mercury production should be gradual with simultaneous development of other production processes based on the existing capacities and infrastructure of the Khaidarkan Mercury Combine.

The closure of large mercury mines in Europe (Almaden, Idrija) over the last decade has shown that there are feasible alternative development options. The process of the mine' closure and reorganization takes a long time and requires the support and participation of government as well as the interested international organizations and donors.

In 1998-1999, when the design of a master plan for the development of the Kyrgyz mining industry was in progress, Japanese geologists working under JICA assignment admitted that conversion of Khaidarkan Mercury Combine into a facility to process ore from nearby gold deposits was the most promising option.

In October 2009, at the International Forum in Bangkok (Thailand) the Kyrgyz delegation presented the Action Plan on production of primary mercury and environmental impact assessment. This Action Plan was developed with the participation of leading ministries and approved by the Government of the Kyrgyz Republic. The delegation stressed the need for further review of the options and opportunities for the conversion of the combine.

The present report is an input into the study of the opportunities for the conversion of the combine. It has been prepared in a format comparable to the pre-feasibility study. This report is not a final one, but rather an initial stage in the work on possibilities for conversion. In particular, it analyses the economic and environmental advisability of various options. The study is based on earlier work and calculation made by the Ken-Too Design and Research Centre using the current cost of equipment, infrastructure and product pricing.

The Ken-Too Design and Research Centre is a competent local design organization with a large experience of work in Kyrgyzstan. It holds the necessary licenses for project design and surveys. The Kyrgyz Mining Association has a profound knowledge of the physical situation and the investment environment in the Kyrgyz mining industry. It maintains contacts with a large number of operators and investors. The Swiss Zoï Environment Network closely cooperates with the UNEP Chemicals and works with both public agencies and NGO partners in Kyrgyzstan, on a number of aspects including chemical substances and assessment of environmental and safety risks.

Currently, the rights for the development of gold deposits located in the neighbourhood of KMC, which is a state-run enterprise, belong to various private companies. On the one hand, this complicates the situation and cooperation, but, on the other hand, it creates opportunities for public-private partnership. An insufficient level of knowledge about the deposits (reserves approved by the State Reserves Committee "GKZ" are only available for the Altyn-Dzhylga deposit) brings uncertainty into the calculations. In addition to gold ,this study also considers the options to develop other mineral deposits, such as bentonite, gypsum etc.

1. Opportunities related to mining and extraction (concentration) of gold using the potential of Khaidarkan Mercury Combine

The option of processing gold-containing ore from the nearest deposits at KMC was recommended as early as in 1999 by Japanese experts of Mitsui (under JICA assignment) while studying the mining potential of the Batken province. This conversion option is the most probable one since it takes account of equipment and structures, professional human resources, infrastructure, transport, repair base, allocated land area of KMC.

In Batken region, there are 25 different scale gold ore occurrences. Four of them are middle-size deposits in terms of reserve amount (Altyn-Dzhylga, Chakush, Nichkesu, Kanyzak), and over ten deposits are small-size objects (Aprelskoye, Karasang, Gavian, Duva-Tash, Yuzhnoye, Chonkimisdykty, Kugandy, Dzhumasu etc).

Below is a brief characteristic and calculation of economic efficiency indicators for development of gold deposits closest to Aidarken and planned to be covered by mining operations. Economic efficiency and environmental impact of gold deposit development projects are considered in two comparable options:

1. traditional one with construction of gold concentration plant and tailings pond at each deposit;
2. with ore processing at a cluster (regional) GCP of KMC taking into account extension of the existing plant's capacity to 200 thousand tonnes of ore a year and subsequent construction of a new plant with productivity of over 500 thousand tonnes of ore per year.

1.1 Altyn-Dzhylga deposit

The deposit is located in Batken district, at the joint of Turkestan and Alay Ridges, on the right side of the Sokh River valley. The coordinates of the deposit are: 39º43′ of northern latitude, 70º56′ of eastern longitude. Currently, no work is performed at the deposit and there are two applicants to obtain the license.

The district is a well-developed, easily accessible territory. The nearest Sary-Taala village is 2.5 km away from the deposit. The distance to Aidarken settlement is 50 km. The landscape is sharply dissected. Elevations above the Sokh River valley where the earth road runs are 150-400 m. The altitudes range from 1,800 to 2,400 m.

As of 01.06.2004, the following reserves were accounted in the state balance: C_2 category – 1.79 thousand tonnes, gold – 9.5 tonnes with content AU - 8 g/t and P_1 category – 6.196 million tonnes, gold – 21 t with content of 3.4 g/t. The total of two categories C_2+P_1: ore – 7.375 million tonnes, gold – 30,570 kg with the content of 4.14 g/t.

The updated reserve calculations (information as of 2010) are presented below. Gold cut-off grade (2 g/t) and minimum gold content for block mapping (3 g/t) are used.

Table 1.1

Updated estimates of Altyn-Dzhylga deposit's reserves and resources

Reserves and resources	Ore mass, thousand tonnes	Metal content			Metal mass		
		Au g/t	Ag g/t	Cu %	Au kg	Ag kg	Cu T
Central Block of Altyn-Dzhylga Deposit (Pikhota, 2000**)**							
C_2	3,194	3.98	1.97	0.63	12,704	6,306	2,023
P_1	2,680	1.79	1.28	0.038	4,805	3,433	1,022
Yuzhniy (Southern) Block of Altyn-Dzhylga Deposit (Koloskov, 2007**)**							
C_2	667	12.15	28.68	1.66	8,103.4	19,133	11,071
P_1	1,332.8	12.43	26.48	0.95	1,659.8	35,300	12,701

The total reserves obtained in estimations by N.A. Pikhota (2000) and V.P. Koloskov (2007) in C_2 category are 20 tonnes of gold with the content of 5.4 g/t and predicted resources are 21 tonnes of gold with the content of 5.3 g/t. The aggregate amount is 42 tonnes of gold, which is almost double the amount of resources accounted in the state balance. In view of this fact, additional prospecting and exploration of the deposit is required.

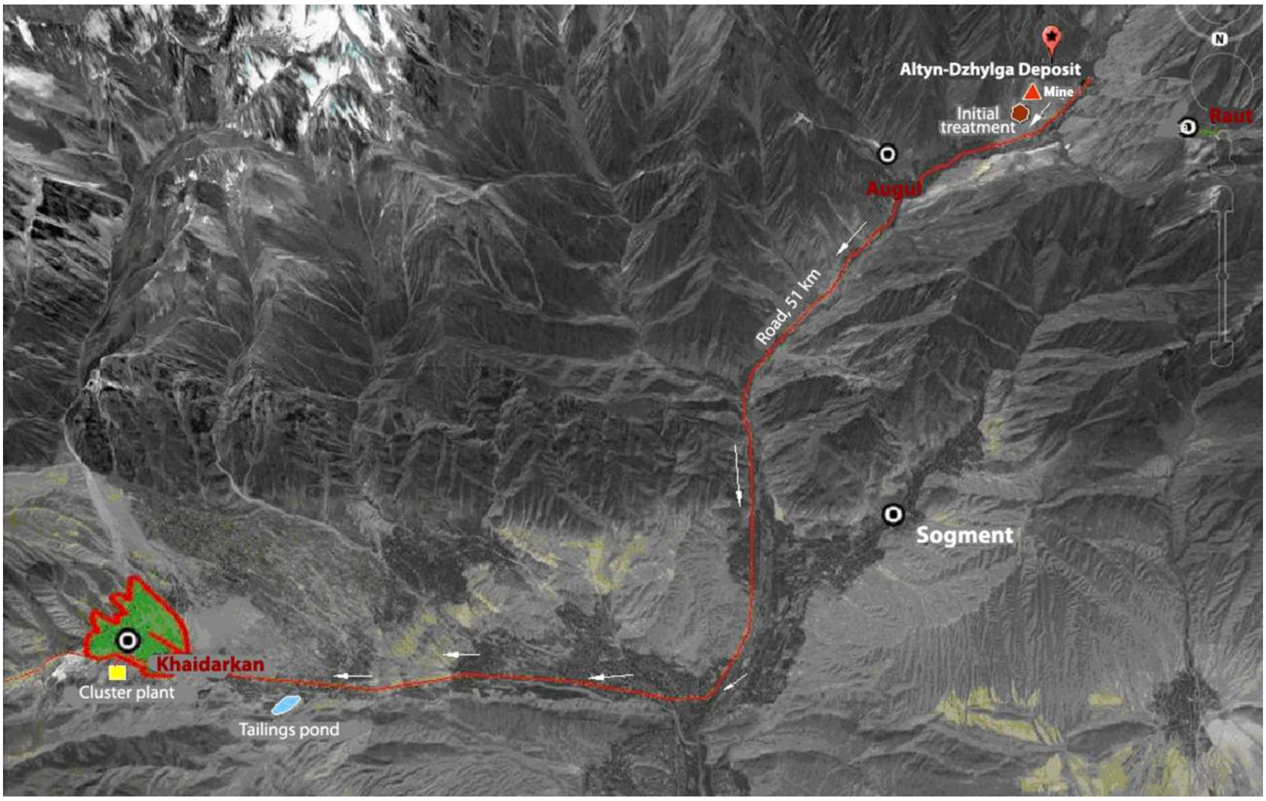


Fig. 1.1 Location of Altyn-Dzhylga deposit

Main provisions for development of the deposit

Altyn-Dzhylga deposit is an object for underground drift-based mining. The production capacity of the deposit is set up to 500 thousand tonnes of ore (Au content in the ore is 5.4 g/t) per year with the work under rotational system and the duration of the rotation shift of 15 days. The reserves are sufficient for over 9 years of operation with the total number of employees being 400-600 persons.

Proposed infrastructure of the mine:

- rotational village for 200 people with water intake and treatment facilities;
- storehouse, compressor station, machinery and repair shops;
- laboratory, diesel-fuelled power station, substation, 50 km electricity transmission line
- 5 km access road and 10 km technological motor roads;
- rent of Isfara railroad base in Tajikistan;
- 30 motor vehicles;

Altyn-Dzhylga deposit is represented by sulphide ore with high content of arsenic sulphides and antimonous sulphides. According to the preliminary laboratory studies, extraction of gold for concentrate under flotation-cyanidation scheme has made 92%, that under gravity-cyanidation scheme has been 90%, gold extraction under gravity-flotation-cyanidation scheme has been 91% and under direct leaching (cyanidation) – 89%. Taking into account high content of arsenic it is recommended to apply gravity-flotation scheme.

Process flow operations:

- Ore crushing and grinding;
- Gravity and flotation treatment;
- Condensation and flotation of concentrate, subsequent drying and burning;
- Extraction of arsenic and antimony;
- Gold leaching

Table 1.2

Reference data used for economic assessment of underground reserve development of Altyn-Dzhylga deposit

Indicators	Meas. unit	Values	
		Concentration plant at the deposit	Concentration plant in Aidarken
Mineable ore reserves	thousand tonnes	3,861	3,861
Gold content	g/t	5.4	5.4
Reserves of gold	kg	20,849.40	20,849.40
Extraction	%	85	85
Commercial output, total	kg	17,721.99	17,721.99
	oz	569,775.15	569,775.15
Years of deposit development	years	9	9
Annual output: ore	thousand tonnes	500	500
Annual output: metal	kg	2,295	2,295
Number of employees	person	600	450

Results of the economic efficiency calculation for the project of underground reserve development at Altyn-Dzhylga deposit are given in table 1.3.

Table 1.3

Summary of commercial efficiency indicators for development of underground reserves of Altyn-Dzhylga deposit for the entire operation period

Indicators	Meas. unit	Values	
		Concentration plant at the deposit	Concentration plant in Aidarken
Prices for metal Au	$/oz	1,000	1,000
	$/gram	32.15	32.15
Commercial product	thousand USD	569,775.2	569,775.2
Refining costs	thousand USD	2,848.9	2,848.9
Proceeds from sale of commercial product	thousand USD	566,926.3	566,926.3
Capital expenditures	thousand USD	94,624	57,805
Working capital	thousand USD	1,759	2,217
Operational expenditures	thousand USD	271,678	342,456
Reclamation	thousand USD	4,030	4,395
Taxes and deductions	thousand USD	37,519	39,685
Income tax (10%)	thousand USD	19,804	14,422
Cash flow	thousand USD	139,270	108,163
Net present value (NPV)	thousand USD	17,697	18,094
Internal rate of return (IRR)	%	21.13	24.20
Capital expenditure pay-back period	years	4.2	3.8

Conducted calculations demonstrate economic efficiency of the deposit development. Besides, the second deposit development option with GCP at KMC is the most preferable one as its efficiency indicators (net present value, internal rate of return and capital expenditure pay-back period) are higher.

To verify the stability of the estimated project's commercial efficiency indicator (GCP at KMC), net present value, analysis of its sensitivity to the change of the key parameters (geological – commercial element content; economic – prices for gold, capital expenditures and operational costs) was carried out. The diagram of the net present value's sensitivity to the above parameters is shown below.

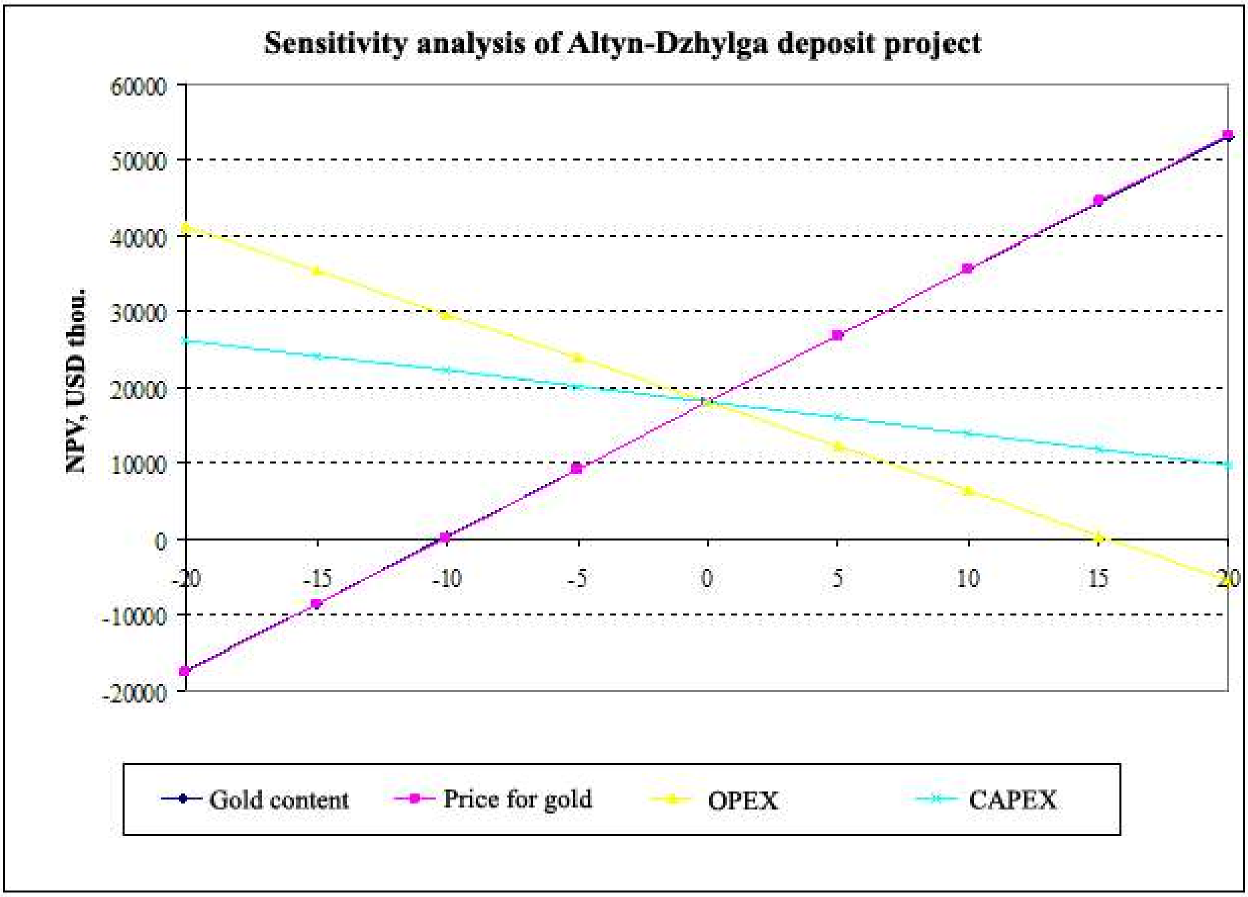


Fig. 1.2. Change in the net present value resulting from modification of the key investment project parameters

The strongest impact on NPV is caused by the external factors: gold content and prices. Downward change by more than 10% from the today's level can make the project unprofitable (given that other factors remain unchanged). The price of gold used in the calculations is 1,000 $/ozt. As of today, it has reached 1,700 $/ozt. With such price level, NPV doubles and processing of ore at the cluster plant becomes even more preferable. Next factor relevant in terms of its impact is operational expenditures. If the cost goes up by 15%, the project becomes unprofitable.

CONCLUSIONS:

1. Preliminarily calculated economic efficiency of developing underground reserves of Altyn-Dzhylga deposit shows high commercial efficiency of the project with concentration plant located in Aidarken: net present value –18,094 thousand USD, internal rate of return – 24.2%, investment pay-back period – 3.8 years.

2. The project seems to be relatively stable to risks: change of only capital expenditures by ± 20% does not lead to the project's unprofitability.

Potential environmental impact of Altyn-Dzhylga's concentration plant

The area where Altyn-Dzhylga deposit is located is favourable for location of the concentration plant, tailings pond, infrastructure facilities and rotation village. Construction of a motor road for heavy trucks bypassing populated areas has been commenced. Transportation of ore to KMC's GCP will require 17 tipping trucks with capacity of 30 tonnes each, making 3 trips per twenty-four hours. The existing village roads with earth surface are not suitable for heavy truck traffic. 1-2 km away from the deposit there is the Sokh River that is full flowing and rapid during the spring and summer period.

Local population is occupied in agriculture, horticulture (apricot gardens). The population is against the location of the concentration plant with tailings pond near the deposit. No land allocation permit for the concentration plant has been issued by local authorities.

The following environmental impact is possible if GCP, tailings pond and infrastructure facilities are located near Altyn-Dzhylga deposit:

- 500 thousand tonnes of industrial waste per year will be delivered to the tailings pond (tailings from flotation and cyanidation processes);
- water will be supplied from the Sokh River in an amount of 2 million m^3 (recycled water – 1,617,000 m^3, clean water – 650,000 m^3) with specific water consumption of 4.5 m^3 per 1 tonne of ore.
- over 100 tonnes of atmospheric emissions a year (mostly non-organic dust)

Fig. 1.3. General view of the area where Altyn-Dzhylga deposit is located

1.2 Chakush deposit

The deposit is located in Batken district, on the northern slope of Kuruksay Mountains that are part of Alay Mountain Ridge, 10 km to the north of Altyn-Dzhylga deposit on the left bank of the Sokh River, in the well-developed and populated district, 40 km away from Aidarken settlement. A motor road passing along the right bank of the Sokh River links the deposit with the settlement. There is no bridge over the Sokh River suitable for motor transport. Elevation of the surface is 1,500-2,300 m above the sea level. The landscape is extremely desiccated. The slopes' steepness is 30-45^0. Some of the slopes are cliffed. The distance to the closest populated area (Augul settlement) is 4 km. The distance to Isfana-Batken-Osh motor road running through Aidarken settlement is 20 km, the distance to the railway line is 69 km. 10 kV electricity transmission line goes along the motor road. The distance to 35 kV electricity transmission line is 20 km (Sokh substation).

The extent of the deposit's exploration is insufficient that is why all estimations are indicative. To obtain reliable reserve estimations it is necessary to carry out geological prospecting and exploration including 18 thousand m of underground mine workings, 10 thousand m of drilling, trenches, bulldozer strippings, topographic mapping, process testing.

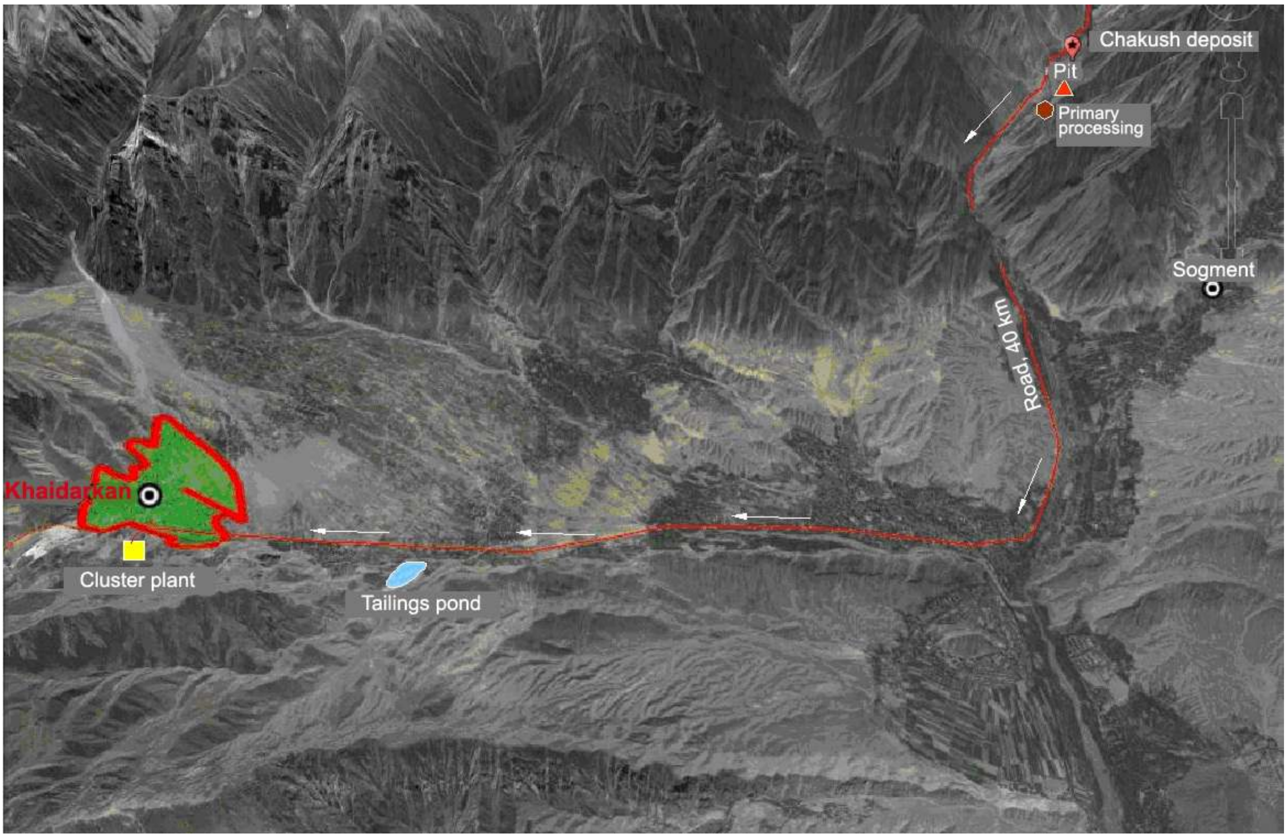


Fig. 1.4. Location of Chakush deposit

Six blocks of quartz veins with gold content and 18 ore bodies were identified at the deposit. Approximate reserves of the gold deposit according to the estimation made ten years ago are 30 tonnes including 9.4 tonnes of C_2 category and 20.6 tonnes of predicted resources. The content of gold is uneven, up to 50 g/t, the average being 7.4 g/t. The associated component is silver with the average content of 24 g/t.

Mineable ore reserves of the deposit are 2,660 thousand tonnes, 17 tonnes of gold and 58 tonnes of silver. The optimal productivity of the mine is 200 thousand tonnes of ore per year. Life cycle of the deposit is 13-15 years, the number of employees - 350 persons.

Flotation scheme is chosen for ore processing and feeding of concentrate for further treatment. The level of gold extraction is 90% and that of silver is 70%.

Building of the tailings pond is possible in dry gully on the left bank of the Sokh River, 250 m away from the concentration plant. The total capacity of the tailings pond is 900 thousand m^3, which makes it possible to place about 1.3 million tonnes of tailings or 50% of the produced ore. It is necessary to find some solutions to place the other 50% of ore.

The results of efficiency calculation for Chakush deposit's reserve development project are given below. The calculations confirm economic efficiency of the deposit's development. Risk-associated nature of the investments is taken into account through the discount rate of 15%. With that, the second deposit development option (GCP at KMC) is the most efficient one.

Table 1.4

Reference data used for economic assessment of underground reserve development at Chakush deposit

Indicators		Meas. unit	Values	
			Concentration plant at the deposit	Concentration plant in Aidarken
Mineable ore reserves:		Thousand tonnes	2,658.3	2,658.3
Content:	Au	g/t	6.4	6.4
	Ag	g/t	21.57	21.57
Reserves	Au	kg	17,013.12	17,013.12
	Ag	kg	57,339.53	57,339.53
Extraction:	Au	%	90.25	90.25
	Ag	%	58.1	58.1
Commercial output, total:	Au	kg	15,354.34	15,354.34
	Au	oz	493,653.47	493,653.47
	Ag	t	33,314.27	33,314.27
Deposit development period:		years	14	14
Annual productivity: ore		thousand tonnes	200	200
Headcount		persons	456	350

Table 1.5

Summary of commercial efficiency indicators for development of underground reserves of Chakush deposit for the entire operation period

Indicators		Meas. unit	Values	
			Concentration plant at the deposit	Concentration plant in Aidarken
Prices for metal	Au	$/oz	1,000	1,000
	Au	$/g	32.15	32.15
	Ag	$/g	0.55	0.55
Commercial product		thousand USD	511,976.3	511,976.3
Refining costs		thousand USD	2,468.27	2,468.27
Proceeds from sale of commercial product		thousand USD	509,508	509,508
Capital expenditures		thousand USD	64,782	46,027
Working capital		thousand USD	2,625	2,802
Operational expenditures		thousand USD	192,508	205,503
Reclamation		thousand USD	2,929	2,872
Taxes and deductions		thousand USD	35,666	35,666
Income tax (10%)		thousand USD	22,675	22,565
Cash flow		thousand USD	190,948	196,875
Net present value (NPV)		thousand USD	33,034	41,470
Internal rate of return (IRR)		%	29.72	39.20
Capital expenditure pay-back period		years	3.4	2.7

To verify the stability of the assessed project's commercial efficiency indicator (GCP at KMC), net present value, analysis of its sensitivity to the change of the key parameters (geological – commercial element content; economic – prices for gold and silver, capital expenditures and operational costs) was carried out. The diagram of the net present value's sensitivity to the above parameters is shown in fig. 1.5.

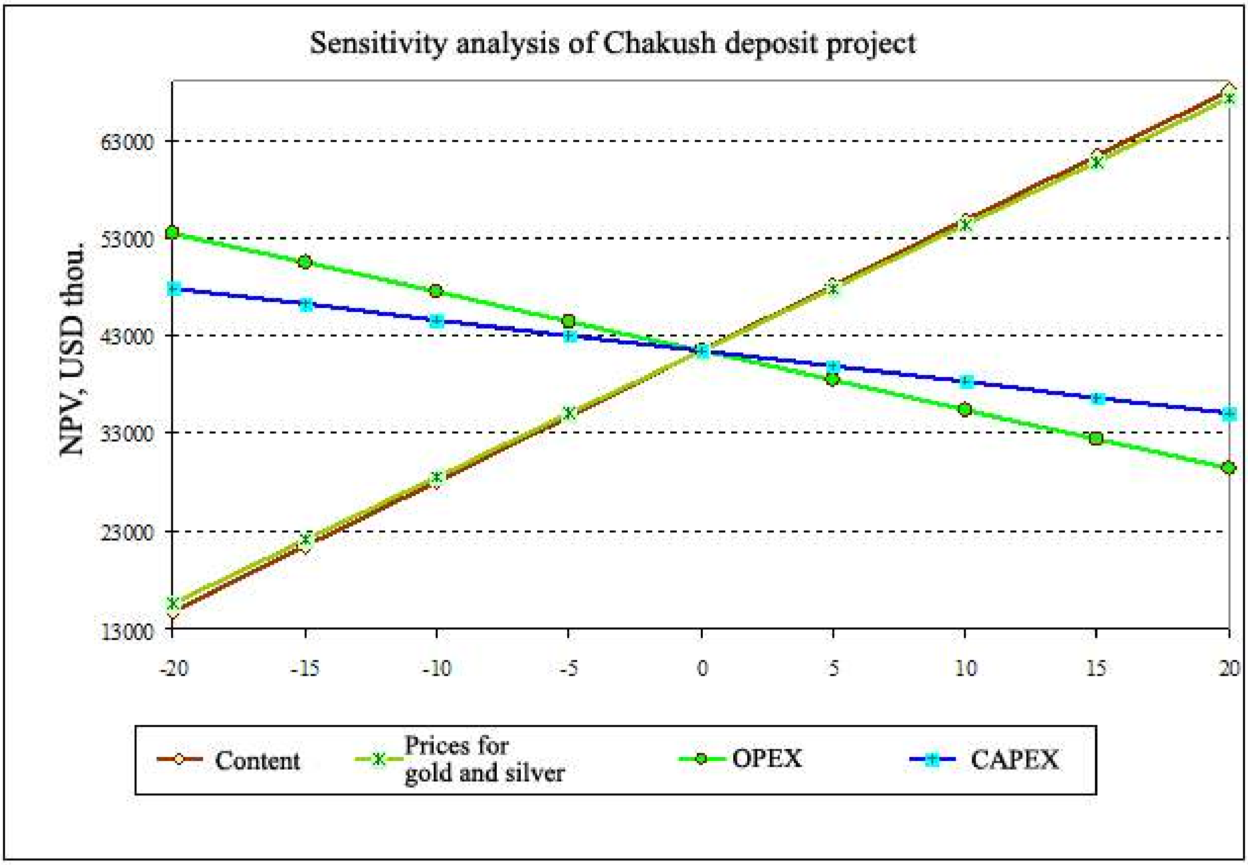


Fig. 1.5. Change in the net present value resulting from modification of the key investment project parameters

The strongest impact on NPV is made by external and internal factors: prices for gold and silver and content of metals in ores. Other factor relevant in terms of its impact is operational expenditures.

CONCLUSIONS:

1. Preliminarily calculated economic efficiency of developing the reserves of Chakush deposit confirms high commercial efficiency of the project with the concentration plant located in Aidarken: net present value – 41,470 thousand USD, investment pay-back period – 2.7-3 years, internal rate of return – 39.2% (30% higher than in case of ore processing in situ).

2. The project is stable to possible risks: change of prices for gold and silver, content of commercial component, capital expenditures and operational expenditures in the range of ± 20% does not make the project unprofitable.

Potential environmental impact of the Chakush deposit's concentration plant

Chakush gold ore deposit is located in the middle mountain area occupied by distant pastures. If GCP with tailings pond and infrastructural facilities is located near the deposit, allocation of 100 ha of land will be necessary. To the south of the deposit, there is an ancient tower that has a historical value.

Fig. 1.6. General view of Chakush deposit

Annual fresh water demand of the mine and GCP is 437 thousand m^3. Annual water consumption rate for ore processing is 620 thousand m^3 (3.1 m^3/t of ore). The total volume of the contemplated tailings pond is 903 thousand m^3. This capacity is only sufficient for half of the produced ore. The other half will require surveying and exploration at a distance from the deposit. With the concentration plant's design capacity of 200 thousand tonnes of ore per year, the average atmospheric emissions will be about 50 t per year. Seven tipping trucks of 30 t each will be needed for ore transportation to the KMC's concentration plant. Each of the trucks will make 3 trips per twenty-four hours.

1.3 Duva-Tash deposit

The deposit is located on the territory of Batken district, on the right bank of Aksy Brook near Sogment village. The area is 1,700 m above the sea level. Height differences are 200-250 m. The slopes are up to 40º steep without tree and shrub vegetation. The distance to Aidarken settlement via the roads with asphalted surface is 30 km. The distance via the earth roads bypassing Uzbek Sokh enclave is also 30 km.

In 1995-2003, the deposit underwent detailed exploration from the surface and by means of drilling. Ore occurrences are concentrated in three ore-bearing zones 4,000 m long. Their thickness varies from 1-8 m to 5-28 m. Fluctuations of gold content are from 3.4 to 5.1 g/t. Detailed prospecting and exploration is required to determine the commercial reserves of the deposit.

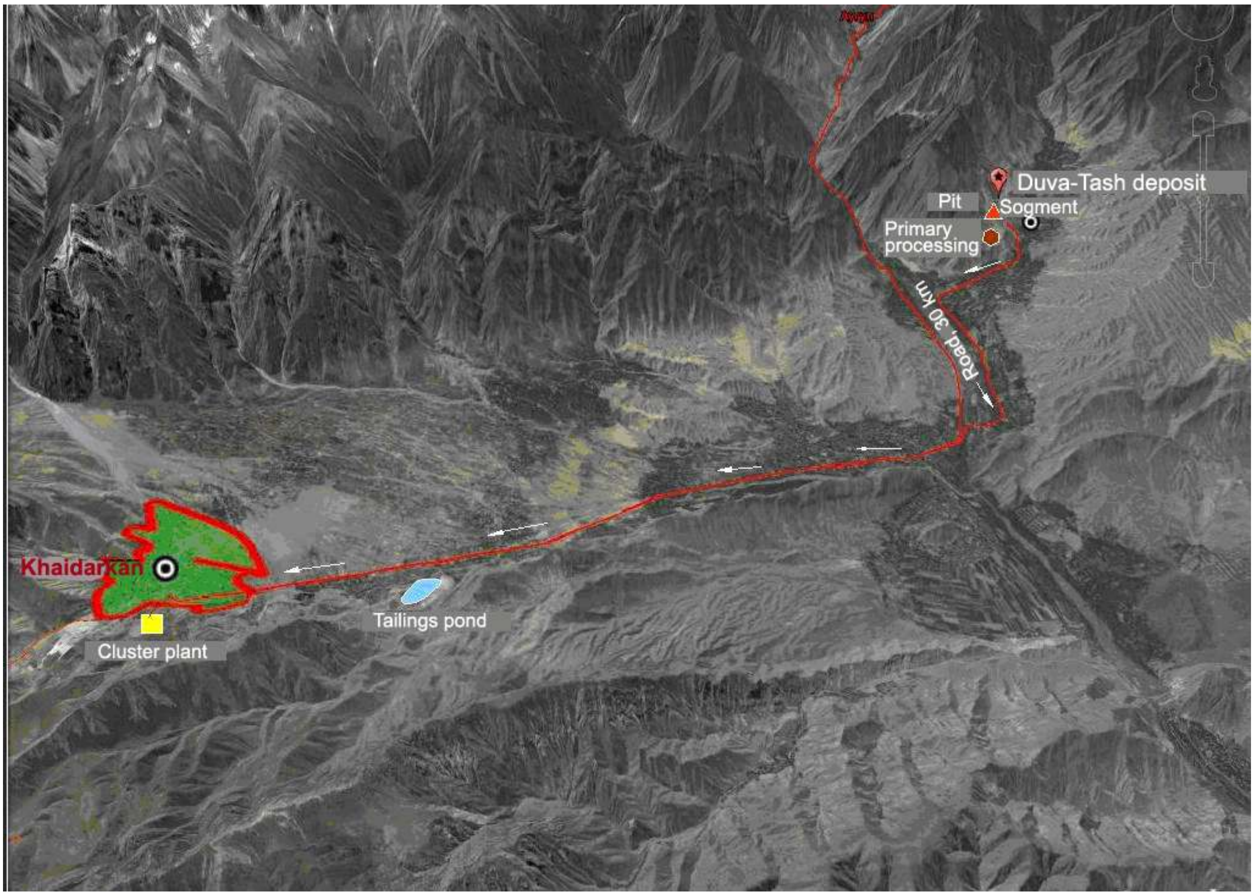


Fig. 1.7. Location of Duva-Tash deposit

Predicted gold resources are 19.8 t with the content of 4.05 g/t. The amount of ore is 4.9 million tonnes. Reserves and resources have not been approved by the State Reserves Committee of the Kyrgyz Republic.

License for exploration of the deposit belongs to joint Kyrgyz-Australian Jany Jyldys Gold Limited Liability Company that continues drilling operations.

The production capacity of the mine is set to be 150 thousand tonnes of ore per year with geological reserves of 1,721 thousand tonnes of ore. Concentration plant and tailings pond can be built in the valley of the blind creek to the north of the deposit.

Specific testing of the deposit's ore has not been carried out that is why ore processing technology is chosen by analogy with other skarn deposits (Bozymchak, Kuru-Tegerek). In case of the flotation-based processing method, the rate of gold extraction to concentrate is assumed to be 86%. Concentrate output is 4% or 20 thousand tonnes. Ore processing to receive flotation concentrate is applied in order to exclude cyanidation process on site and to simplify the structure of the concentration plant and the tailings pond.

Table 1.6

Reference data used for economic assessment of underground reserve development at Duva-Tash deposit

Indicators		Meas. units	Values	
			Concentration plant at the deposit	Concentration plant Aidarken
Mineable ore reserves:		thousand tonnes	1,721	1,721
Content:	Au	g/t	4.756	4.756
Reserves	Au	kg	8,185.08	8,185.08
Extraction:	Au	%	76.505	76.505
Commercial output, total:	Au	kg	6,261.99	6,261.99
	Au	oz	201,327.71	201,327.71
Period of deposit development:		years	13	13
Annual output: ore		thousand tonnes	150	150
Annual output: metal		kg	545.79	545.79
Number of employees		persons	250	200

Table 1.7

Summary of commercial efficiency indicators for development of underground reserves of Duva-Tash deposit for the entire operation period

Indicators	Meas. unit	Values	
		Concentration plant at the deposit	Concentration plant in Aidarken
Prices for metal Au	$/oz	1,000	1,000
	$/g	32.15	32.15
Commercial product	Thousand USD	201,327.70	201,327.70
Refining costs	Thousand USD	1,006.60	1,006.60
Proceeds from sale of commercial product	Thousand USD	200,321.10	200,321.10
Capital expenditures	Thousand USD	31,201	18,300
Working capital	Thousand USD	414	453
Operational expenditures	Thousand USD	113,974	124,835
Reclamation	Thousand USD	1,551	1,531
Taxes and deductions	Thousand USD	10,016	10,016
Income tax (10%)	Thousand USD	5,574	5,225
Cash flow	Thousand USD	38 005	40 413
Net present value (NPV)	Thousand USD	203	5 369
Internal rate of return (IRR)	%	15.21	23.16
Capital expenditure pay-back period	years	5.6	4.2

The above calculations confirm economic efficiency of the deposit's development. With that, the second deposit development option (GCP at KMC) is most efficient.

To verify the stability of the assessed project's commercial efficiency indicator (GCP at KMC), net present value, analysis of its sensitivity to the change of the key parameters (geological – commercial element content; economic – prices for gold, capital expenditures and operational expenditures) was carried out. The diagram of the net present value's sensitivity to the above parameters is shown in fig. 1.8.

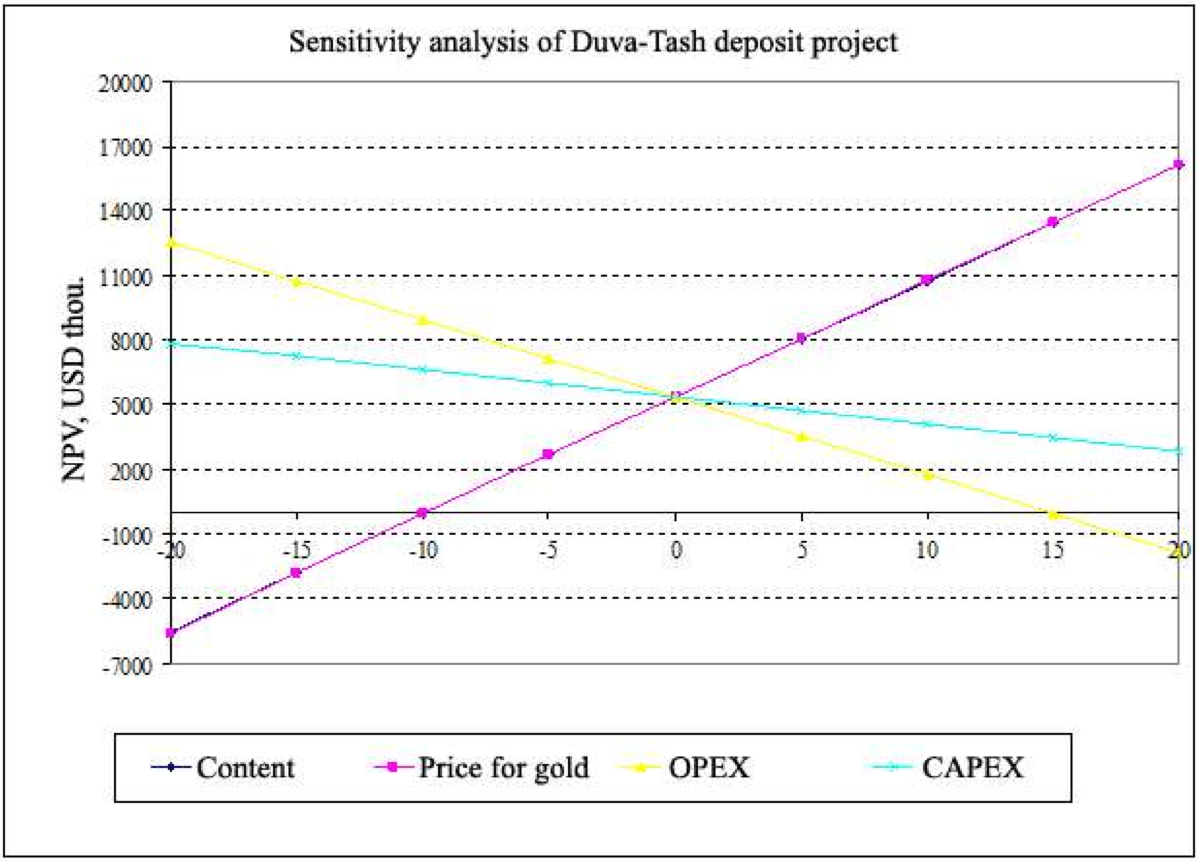


Fig. 1.8. Change in the net present value resulting from modification of the key investment project parameters

The strongest impact on NPV is caused by prices for gold and content of metal in ore. Downward change by 10% from the today's level can make the project unprofitable (given that other factors remain unchanged). Next factor relevant in terms of its impact is operational expenditures. If the cost goes up by 15%, the project becomes unprofitable.

CONCLUSIONS:

1. Preliminarily calculated economic efficiency of developing underground reserves of Duva-Tash deposit shows high commercial efficiency of the project with concentration plant located in Aidarken: net present value – USD 5,369 thousand, internal rate of return – 23%, investment pay-back period – 4.2 years.
2. The project seems to be relatively stable to risks: change of only capital expenditures by ± 20% does not lead to the project's unprofitability.

Potential environmental impact of Duva-Tash deposit's beneficiation/concentration plant

Geological prospecting and exploration is currently in progress at the deposit. The deposit is available for mining operations. Sogment settlement is separated from the mining site by the mountain massif.

There is a land for location of GCP and tailings pond not far from the deposit. The source of water supply for GCP has not been determined.

There is an earth road from the deposit to the Sokh River suitable for heavy-load traffic. Further on, construction of new motor road (15 km) to bypass Uzbek Sokh enclave and new bridge over the Sokh River is necessary.

If GCP with tailings pond and infrastructure facilities is planned to be located near Duva-Tash deposit, 60 hectares of land will have to be allocated. Operation of GCP will result in disposal in the tailings pond of 148 thousand tonnes of production waste a year given the plant's productivity of 150 thousand tonnes of ore per year. The source of water supply for process needs of the gold concentration plant will be the Sokh River. Water consumption by GCP will be 675 thousand m^3/year. Atmospheric emissions are estimated at the level of 35-40 tonnes a year mainly in the form of non-organic dust. Transportation of ore to the beneficiation plant of KMC would require 4 tipping truck of 30 tonnes each. One truck has to make 4 trips in 24 hours.

Fig. 1.9. General view of Duva-Tash deposit

1.4 Gavian deposit

The deposit is located in the upper reaches of the Gauyan River, 3,200-3,500 m above the sea level. Dalniy block is located 2.5 km to the south-west, 3,900 m above the sea level. Coordinates of the deposit: 39º 47′ of northern latitude, 71º20′ of eastern longitude. The nearest populated area, Aidarken settlement, is 20 km to the north down the valley of the Gauyan River where there is bridle road (10 km) further replaced by motor road. The deposit has not been explored and ore testing has not been carried out. At the moment, no operations are conducted at the deposit. The license has not been issued (revoked).

Building of 15 km road and 20 km 10 kV electricity transmission line to the deposit is necessary. Water from the Gauyan River will be used for water supply to the deposit. Water can be supplied by gravity flow via 1 km long waterway. Gold content in the deposit's ore is 11 g/t, that of silver is 20 g/t. The total gold reserves are estimated to be 1.5 tonnes, those of silver – 3 tonnes. Ore bodies of the deposit are scattered over the area of about 12 km^2 and are insufficiently explored. Ore occurrence can be developed by open-cast method. In such case, overburden ratio will be 10 m^3/m^3 (3.33 m^3/t) taking into account complicated location of ore on the surface (steep rock slope).

Fig.1.10. General deposit layout scheme

Gravity-flotation beneficiation scheme is proposed for ore processing and hydrometallurgical processing scheme with preliminary leaching and subsequent cyanidation. Annual productivity of the plant can be 50 thousand tonnes of ore.

Table 1.8

Reference data used for economic assessment of reserve development at Gavian deposit

Indicators		Meas. unit	Values	
			Concentration plant at the deposit	Concentration plant in Aidarken
Mineable ore reserves:		thousand tonnes	142.20	142.20
Content:	Au	g/t	10.383	10.383
	Ag	g/t	19.915	19.915
	Cu	%	0.86	0.86
Reserves	Au	kg	1,476.46	1,476.46
	Ag	kg	2,831.91	2,831.91
	Cu	t	122.29	122.29
Extraction:	Au	%	73.44	73.44
	Ag	%	59.77	59.77
	Cu	%	61.2	61.2
Commercial output, total:	Au	kg	1,084.31	1,084.31
	Au	oz	34,861.51	34,861.51
	Ag	kg	1,692.63	1,692.63
	Cu	t	748.43	748.43
Period of deposit development:		years	3	3
Annual output: ore		thousand tonnes	120	100
Number of employees		people	50	50

Table 1.9

Summary of commercial efficiency indicators for development of Gavian deposit

Indicators	Meas. unit	Values	
		Concentration plant at the deposit	Concentration plant in Aidarken
Prices for metals Au	$/oz	1,000	1,000
Au	$/g	32.15	32.15
Ag	$/g	0.55	0.55
Cu	t	7,000	7,000
Commercial product	Thousand USD	41,031	41,031
Refining costs	Thousand USD	174	174
Proceeds from sale of commercial product	Thousand USD	40,857	40,857
Capital expenditures	Thousand USD	19,790	15,900
Working capital	Thousand USD	719	881
Operational expenditures	Thousand USD	9,697	11,869
Reclamation	Thousand USD	282	270
Taxes and deductions	Thousand USD	1,226	1,226
Income tax (10%)	Thousand USD	1,348	1,358
Cash flow	Thousand USD	8,514	10,234
Net present value (NPV)	Thousand USD	1,133	2,808
Internal rate of return (IRR)	%	19.32	27.90
Capital expenditure pay-back period	years	2.2	2

The conducted calculations confirm economic efficiency of the deposit's development. With that, the second deposit development option (GCP at KMC) is the most efficient one.

To verify the stability of the assessed project's commercial efficiency indicator (GCP at KMC), net present value, analysis of its sensitivity to the change of the key parameters (geological – commercial element content; economic – prices for gold, capital expenditures and operational expenditures) was carried out.

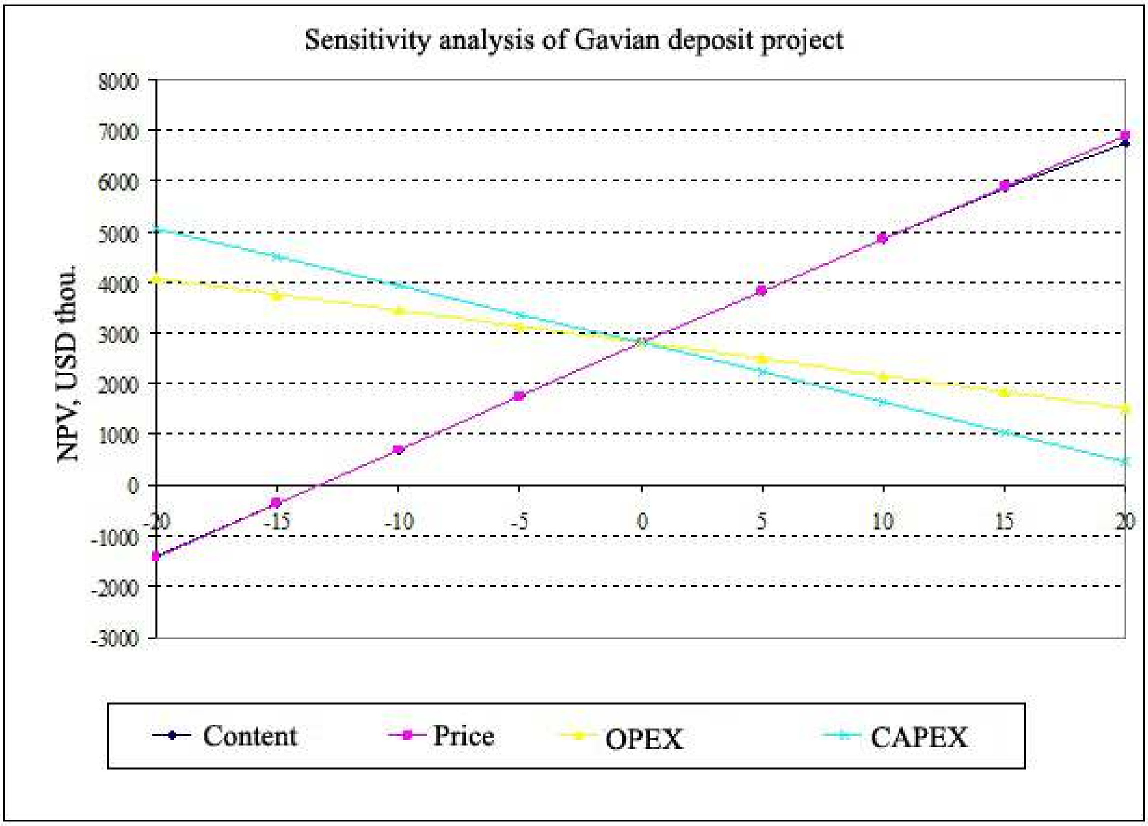


Fig. 1.11. Change in the net present value resulting from modification of the key investment project parameters

The strongest impact on NPV is caused by external factors: prices for mineral raw materials and content. Downward change by more than 10% from the today's level can lead to the loss of the project's profitability (given that other factors remain unchanged). Next factor relevant in terms of its impact is capital expenditures.

CONCLUSIONS:

1. Preliminarily calculated economic efficiency of developing underground reserves of Gavian deposit shows commercial efficiency of the project with concentration plant located in Aidarken: net present value – USD 2,808 thousand, internal rate of return – 27.9%, investment pay-back period – 2 years.

2. Te project seems to be relatively stable to risks: change of only capital expenditures and operational expenditures by ± 20% does not lead to the project's unprofitability.

Potential environmental impact of Gavian deposit's beneficiation/concentration plant

Gavian deposit is located deep in the mountains and does not have any access roads. Pure water of the Gauyan River is used for supply of water to KMC, Aidarken settlement and the nearest populated areas. The ravine is covered by red-mantled forests that are subject to cut-over at the construction site if construthe ting the access road. Besides, in case of the deposit development, these forests will also be exposed to dust emission. As a result, change in the quality of water in the Gauyan River can be expected. If the concentration plant is built near the deposit and tailings pond, part of water at the river source will be taken for process needs reducing discharge of the river that may cause shortage of drinking water. These factors already cause concern and protests of local population against the development of industrial infrastructure.

1.5 Aprelskoye deposit

Aprelskoye deposit is located in Layliak district, Batken region. The deposit is located in the northern branches of Turkestan Ridge, in the basin of Almaly Brook that is the left tributary of the Leilek River in its middle reaches. Coordinates of the deposit: 39º46′ of northern latitude and 70º00′ of eastern longitude. The nearest populated area is Ozgurush village located 5 km away from the deposit and connected with Osh-Isfana highway with a 24 km long earth motor road passing along the Leilek River valley.

The deposit is located in the mountainous area with extremely dissected landscape. Elevation above the sea level varies from 1,800 to 2,300 m, relative elevation differences are up to 500 m.

The area of the deposit is a well-developed, densely populated district. Local population is mostly occupied in agriculture. The closest power source is Teshik TP-35/10 kV sub-station from which there is 10 kV electricity transmission line to Ozgorush village.

The highest and most well balanced content of gold is found in quartz-barite-sulphide veins. Some veins contain from 10 to 28 g of gold per one tonne with the thickness of 1.0-6.0 m. Estimated total gold reserves are up to 30 tonnes including 5 tonnes in C2 category. Sample testing results show that ore can be easily subject to cyanidation even when coarse-grained. Since 2002, the right for geological prospecting and exploration belongs to A.Z. International LLC.

The deposit is characterized by favourable landscape profile for mining by means of drifts. The production capacity is set to be 150 thousand tonnes of ore per year. Reserves of the deposit are sufficient for 10 years of mining.

Geological prospecting and exploration are currently in progress at the deposit. There is a land for location of own GCP and tailings pond not far from the deposit.

Table 1.10

Reference data used for economic assessment of Aprelskoye deposit's underground reserve development

Indicators		Meas. unit	Values	
			Concentration plant at the deposit	Concentration plant in Aidarken
Mineable ore reserves:		thousand tonnes	1,562.6	1,562.6
Content:	Au	g/t	6.39	6.39
	Ag	g/t	21.66	21.66
Reserves	Au	kg	9,985.01	9,985.01
	Ag	kg	33,845.92	33,845.92
Extraction:	Au	%	85.4	85.4
	Ag	%	75	75
Commercial output, total:	Au	kg	8,527.2	8 527.2
	Au	oz	274,155.88	274,155.88
	Ag	t	25,378.58	25,378.58
Period of deposit development:		years	12	12
Annual output: ore		thousand tonnes	150	150
Number of employees		people	250	200

Results of the commercial efficiency calculation for the project of Aprelskoye deposit's underground reserve development are given in table 1.11.

Table 1.11

Summary of commercial efficiency indicators for development of underground reserves of Aprelskoye deposit for the entire operation period

Indicators		Meas. unit	Values	
			Concentration plant at the deposit	Concentration plant in Aidarken
Prices for metal	Au	$/oz	1,000	1,000
	Au	$/g	32.15	32.15
	Ag	$/g	0.55	0.55
Commercial product		USD thou.	288,114.1	288,114.1
Refining costs		USD thou.	1,370.78	1,370.78
Proceeds from sale of commercial product		USD thou.	286,743	286,743
Capital expenditures		USD thou.	49,321	33,232
Working capital		USD thou.	1,403	1,784
Operational expenditures		USD thou.	109,595	139,386
Reclamation		USD thou.	1,787	1,926
Taxes and deductions		USD thou.	20,072	20,072
Income tax (10%)		USD thou.	11,896	9,985
Cash flow		USD thou.	94,072	82,143
Net present value (NPV)		USD thou.	14,689	15,949
Internal rate of return (IRR)		%	24.34	29.10
Capital expenditure pay-back period		years	3.6	3.4

The conducted calculations confirm economic efficiency of the deposit's development. With that, the second deposit development option (transportation of ore to GCP at KMC) is the most efficient one.

To verify the stability of the assessed project's commercial efficiency (GCP at KMC), net present value, analysis of its sensitivity to the change of the key parameters (geological – commercial element content; economic – prices for gold and silver, capital expenditures and operational expenditures) was carried out.

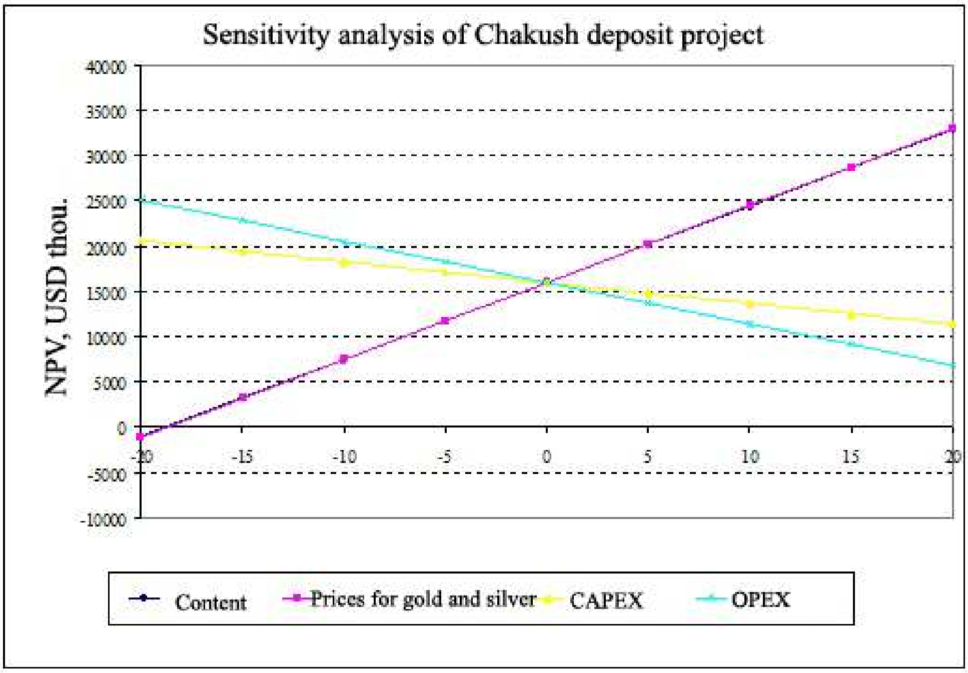


Fig. 1.12. Change in the net present value resulting from modification of the key parameters of Aprelskoye deposit investment project

The strongest impact on NPV is made by external factors: prices for mineral raw materials and content. Downward change by more than 15% from the today's level can lead to the loss of the project's profitability (given that other factors remain unchanged).

CONCLUSIONS:
1. Preliminarily calculated economic efficiency of developing underground reserves of Aprelskoye deposit shows high commercial efficiency of the project with concentration plant located in Aidarken: net present value – USD 15,949 thousand, internal rate of return – 29%, investment pay-back period – 3.4 years.
2. The project seems to be relatively stable to risks: change of only capital expenditures and operational expenditures by ± 20% does not lead to the project's unprofitability.

Potential environmental impact of Aprelskoye deposit's beneficiation/concentration plant

Deposit's ore is characterized by high content of arsenic. Ore beneficiation by gravity-flotation method is envisaged. The intended productivity is 150 thousand tonnes per year. The Liayliak River flowing 1-2 km south-east of the deposit's area can be used as a source of water supply for mining and ore beneficiation.

If GCP with tailings pond and infrastructure facilities is located near Aprelskoye deposit, 100 hectares of land will have to be allocated. Operation of the GCP will result in annual disposal of 138,000 thousand tonnes of flotation and cyanidation waste in the tailings pond. In the course of ore processing, waste containing arsenic will be generated. Construction of secure landfill for its disposal is necessary.

If the gold-containing ore is processed at KMC, ore will be transported by heavy-load vehicles to a distance of 180 km first by the existing earth road (46 km) and then by road with asphalted surface. Eight tipping trucks of 30 tonnes each will be required to transport ore from the deposit. Each of the trucks will have to do make 2 trips per 24 hours.

2. Environmental and economic feasibility of developing Cluster Gold Concentration Plant Project

Today, only the Altyn-Dzhylga deposit has the reserves approved by the State Reserve Commission ("GKZ") of the Kyrgyz Republic. Exploration operations are being accomplished and report with reserve estimation is being prepared for the Aprelskoye deposit. Geological prospecting and exploration is in progress at the Duva-Tash deposit. No work is carried out at the Chakush and Gavian deposits and licenses for their exploration have not been issued. Geological exploration costs for the above deposits in the nearest years can amount to 30 million USD. The fact that various deposits are at different stages of readiness for mining means that they would be put into operation at various times with the gradual increase of productivity of CGCP. This will make it possible to prepare regulation for processing of ore with various mineral and chemical composition, varied gold content and different composition of associated and harmful components or to separate processing of various types of ore at different process lines.

2.1 Brief geographical information and overview of the status of KMC' infrastructure

Aidarken settlement (formerly called Khaidarkan) and mercury plant are located in Khaidarkan Valley (1,700-2,000 m above the sea level) restricted by Alay-Turkestan Ridge in the south and Eshme Mountains in the north. Aidarken is characterized by dry, continental climate with average annual temperature of +6ºC. The lowest temperature in winter is -20ºC, the highest temperature in summer is +25ºC. Average annual level of precipitations is 415 mm.

The population of the settlement is 11 thousand people. Working population is 4.5 thousand people, while the number of employed is 2.5 thousand of which almost one third is employed at the mercury combine. The settlement has 3 markets, 36 private shops and a café.

The settlement is 44 km from Pulgon (Kadamzhay) district centre, Kadamzhay district, and 65 km from Batken city that is the capital of Batken region. The closest railway stations are located in Kyzyl-Kiya Town (Kyrgyzstan) and Margilan Town (Uzbekistan). Commercial cargoes are transported to Aidarken by Uzbek railway line to Margilan station. The nearest international airport is in Osh, 170 km away from the settlement.

The settlement is crossed by Osh-Isfana national motor road. Possibly, intensity of traffic and relevance of this road will reduce in the future as new Kadamzhay-Batken motor road is being built bypassing Uzbek and Tadjik enclaves.

Water pumped from underground mines is discharged into Shakhtniy Brook that is used by inhabitants of Eshme, Sur, Chechme and other settlements for irrigation of lands with a total area of up to 500 hectares (about one fourth of all agricultural lands of Khaidarkan Valley). In Aidarken settlement drinking water is taken from the Gauyan River. Currently, Aidarken settlement and beneficiation plant annually consume about 2-3 million m^3 of water from surface (the Gauyan River) and underground sources. In the past, water consumption by the combine and the settlement reached 4 million m^3. Eventually, mine water is streamed into the Sokh River and other effluents (for example, wastewater from iron and steel production) are discharged onto the surface near the plant.

Aidarken is considered to be a well-developed settlement with operational water supply, sewerage systems and catch basins. Electricity is supplied by subdivision of Oshelektro OJSC. KMC and Aidarken settlement are supplied with electricity via 35 kV electricity transmission line. All costs for maintenance, repair and losses are borne by the enterprise. KMC is an energy-intensive mining enterprise. Pumping units for mine water account for 3.1 million kWh of electricity out of 4.5 million kWh totally consumed by the enterprise per month (average). The settlement is also supplied with gas from Uzbekistan.

The main product of the plant is metallic mercury and its compounds as well as fluoric-spathic concentrate. Since 2008, mining of complex ores and production of concentrate have stopped due to the flooding of complex ore mine.

Beneficiation plant used to process complex ore of Mine no. 2 to obtain fluorspar concentrate. The plant consists of desulphurizing flotation line for extraction of cinnabar and antimonite and the line for flotation of the fluorspar. The plant employs 71 person including 62 workers and 9 engineering and technical specialists. The productivity of the plant is 300 tonnes of ore per day. It was capable of processing 100 thousand tonnes of ore per year. Complex ore is subject to crushing and flotation in the course of the beneficiation. According to the plant's management, the productivity can be increased to 200 thousand tonnes of ore per year. All the equipment of the beneficiation plant is in working condition, but modernization of some units (filtration and drying) is required as well as construction of gold extraction capacities. The level of automation is quite low. Tailings facilities of the beneficiation plant have been in operation since 1967. According to the calculations by Kentor Gold Company, costs for upgrade of the existing beneficiation plant to process gold bearing ore form Savoyardy deposit are estimated to be 2.2 million USD.

Apart from the beneficiation plant, KMC has operational metallurgical plant that processes monometallic mercury ore without beneficiation and mercury waste. The main equipment of the plant is crushing unit, burning furnaces and condenser. It is unlikely that the main part of the plant's equipment will be utilized in case of the combine conversion to be operated for gold extraction.

2.2 Cluster Gold Concentration Plant Project (CGCP)

In 1999, experts of MITSUI geological company (Japan) that studied the prospects for development of KMC recommended continuation of the plant's operation through the development of the nearest gold deposits. In view of the growing world prices for gold, the relevance of this project has grown by now.

It is proposed to study the possibility of building cluster GCP for processing of ore from the nearest gold deposits on the basis of KMC's beneficiation plant.

Altyn-Dzhylga, Chakush, Duvatash, Gavian deposits are located 50-70 km away from KMC and their development should be considered in the first turn. Feasibility of such project is confirmed by Kentor Gold LTD for Savoyardy deposit. The distance from KMC to Savoyardy deposit is 370 km. However, having conducted the preliminary feasibility study, Australian Kentor Gold Company finds ore transportation to KMC's beneficiation plant economically reasonable having determined the general operational expenditures in an amount of USD 370 per one ounce.

According to the conclusion of Kentor Gold, the project of gold ore processing at KMC has a number of advantages over construction of concentration plants and tailings ponds directly at the nearest deposits:

- lower capital expenditures;
- lower environmental impact;
- fewer necessary permits;
- shorter period for mining commencement;
- professional team of employees available at KMC;
- operational infrastructure including power infrastructure;
- available unused processing capacities

These advantages should be complemented with saving of time and material resources for surveying and construction work related to new GCPs and tailings ponds (and approvals from local population), availability of tailings pond at KMC and, most importantly, possibility to commence deposits' development immediately combining mining operations with further prospecting and exploration of the deposits.

The equipment of the plant was manufactured in 1960-80ies. It has been idle since 2008 and is obsolete. Part of the equipment should be replaced.

Apart from conversion of the beneficiation plant of KMC into gold concentration plant (GCP), it will be necessary to gradually increase its capacity from 100 thousand tonnes to 0.5-1 million tonnes per year. It can annually output 6-7 tonnes of gold. The cost of construction of new GCP will be 40-60 million USD and about 300 permanent jobs will be created.

Development of the nearest gold deposits at the same time with ore processing at the cluster GCP can provide 1,250 jobs, which will not only fully compensates for the loss of working places in mercury production, but will double the need for employees.

The project of GCP's construction on the basis of KMC's beneficiation plant is considered as quite realistic and feasible, but requires large organizational arrangement to involve the owners of rights for deposits into the project as well as the necessary approvals from the government of the Republic of Kyrgyzstan.

Table 3.1 gives comparative characteristic of the main technical and economic indicators of the considered gold ore projects under two deposit development options: 1 - traditional, with construction of GCPs and tailings ponds at each of the deposits and 2 – innovative one, with ore processing at CGCP of KMC.

The table shows that ore processing in Aidarken settlement, that is at CGCP of KMC, is the most efficient and profitable for all economic indicators (NPV, IRR, cash flow).

Since the maximum possible ore output from 5 nearest deposits will be up to 1 million tonnes per year (Altyn-Dzhylga, Chakush, Gavian, Duva-Tash, Aprelskoye) and their development will not commence simultaneously, the capacity of the new GCP is intended to be 500 thousand tonnes of ore per year. In this case, the total productivity of 2 GCPs will be 700 thousand tonnes of ore. Construction of new GCP is possible within the site of the existing industrial land near the Novaya mine at Khaidarkan.

Table 2.1.

Comparative characteristic of economic efficiency of gold deposits’ development

Indicators	Meas. unit	GCP at each deposit					CGCP at KMC				
		Altyn-Dzhylga	Chakush	Duva-Tash	Gavian	Aprelskoye	Altyn-Dzhylga	Chakush	Duva-Tash	Gavian	Aprelskoye
Mineable reserves:	thousand tonnes	3,861	2,658.30	1,721	142.20	1,562.60	3,861	2,658.30	1,721	142.20	1,562.60
Content: Au	g/t	5.4	6.4	4.756	10.383	6.39	5.4	6.4	4.756	10.383	6.39
Ag	g/t		21.57		19.915	21.66		21.57		19.915	21.66
Cu	%				0.86					0.86	
Reserves Au	kg	20,849.40	17,013.12	8,185.08	1,476.46	9,985.01	20,849.40	17,013.12	8,185.08	1,476.46	9,985.01
Ag	kg		57,339.53		2,831.91	33,845.92		57,339.53		2,831.91	33,845.92
Cu	t				122.29					122.29	
Extraction: Au	%	85	90.25	76.505	73.44	85.4	85	90.25	76.505	73.44	85.4
Ag	%		58.1		59.77	75		58.1		59.77	75
Cu	%				61.2					61.2	
Commercial output, Au total	kg	17,721.99	15,354.34	6,261.99	1,084.31	8,527.20	17,721.99	15,354.34	6,261.99	1,084.31	8,527.20
Au	oz	569,775.15	493,653.47	201,327.71	34,861.51	274,155.88	569,775.15	493,653.47	201,327.71	34,861.51	274,155.88
Ag	kg		33,314.27		1,692.63	25,378.58		33,314.27		1,692.63	25,378.58
Cu	t				748.43					748.43	
Period of deposit development:	years	9	14	13	3	12	9	14	13	3	12
Annual output: ore	thous. tonnes	500	200	150	120	150	500	200	150	100	150
Number of employees	people	600	456	250	50	250	450	350	200	50	200
Prices for metal Au	$/oz	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Au	$/g	32.15	32.15	32.15	32.15	32.15	32.15	32.15	32.15	32.15	32.15
Ag	$/g		0.55		0.55	0.55		0.55		0.55	0.55
Cu	t				70,00					7,000	
Commercial product	USD thous.	569,775.20	511,976.3	201,327.7	41,031	288,114.10	569,775.20	511,976.3	201,327.7	41,031	288,114.10
Refining costs	USD thous.	2,848.90	2,468.27	1,006.6	174	1,370.78	2,848.90	2,468.27	1,006.6	174	1,370.78
Proceeds from sale of commercial product	USD thous.	566,926.30	509,508	200,321.1	40,857	286,743	566,926.30	509,508	200,321.1	40,857	286,743
Capital expenditures	USD thous.	94,624	64,782	31,201	19,790	49,321	57,805	46,027	18,300	15,900	33,232
Working capital	USD thous.	1,759	2,625	414	719	1,403	2,217	2,802	453	881	1,784
Operational expenditures	USD thous.	271,678	192,508	113,974	9,697	109,595	342,456	205,503	124,835	11,869	139,386
Reclamation	USD thous.	4,030	2,929	1,551	282	1,787	4,395	2,872	1,531	270	1,926
Taxes and deductions	USD thous.	37,519	35,666	10,016	1,226	20,072	39,685	35,666	10,016	1,226	20,072

Income tax (10%)	USD thous.	19,804	22,675	5,574	1,348	11,896	14,422	22,565	5,225	1,358	9,985
Cash flow	USD thous.	139,270	190,948	38,005	8,514	94,072	108,163	196,875	40,413	10,234	82,143
Net present value (NPV)	USD thous.	17,697	33,034	203	1,133	14,689	18,094	41,470	5,369	2,808	15,949
Internal rate of return (IRR)	%	21.13	29.72	15.21	19.32	24.34	24.20	39.20	23.16	27.90	29.10
Capital expenditure pay-back period	Years	4.2	3.4	5.6	2.2	3.6	3.8	2.7	4.2	2	3.4

The existing beneficiation plant at KMC has a tailings pond with the area of 22 ha and capacity of 8.4 million m^3 that is 50% filled. Tailings are fed via 5.5 km pulp line 205 mm in diameter. Today, there is only one pulp line left that needs to be repaired. The pulp distribution line was 1.2 km long. Today, it is not available. Piezometer wells are out of order. Pulp neutralization was made by introduction of chemical agents after concentrate condensing. If cyanidation is planned to be applied, laying of polyethylene film on top of the existing tailings surface and repair of piezometers are necessary for further operation of the tailings pond. In addition, advisability of recycling water supply needs to be reviewed.

During the first years, the new GCP can use the existing tailings pond. The delivery distance will grow up by 0.5 km and will be 6 km.

Other option of GCP construction is at Aygultash site near the former auxiliary facilities. Here, construction of dry tailings storage and organization of recycling water supply without discharge of wastewater is possible. One of the depleted former mercury pits could be used for storage of tailings.

At present, the most probable ore supplier to KMC's GCP is Altyn-Dzhylga deposit which is characterized by availability of tested reserves and negative attitude of local population towards construction of new tailings.

Despite the fact that KMC is a state-run enterprise supported by the government, it does not have free financial resources for modernization of the beneficiation plant, tailings pond and construction of new GCP and tailings pond. The project of KMC's conversion could be implemented through public-private partnership with participation of international banks or through other financial channels (not excluding privatization of KMC if mercury production is refused).

2.3 Social aspects of KMC's conversion

At present, KMC employs over 500 persons (staffing list includes 850 employees). This is 4-5 times less compared to the Soviet time. If the mining and mercury production is closed without any alternatives offered, then jobs and equipment will be lost, financing of social infrastructure (community centre, preventive healthcare center), settlement's infrastructure (hotel, water supply, power supply) will be reduced, number of working places in indirect employment and induced employment will be reduced. That would result in the growth of internal and external migration of the population along with the increase of the social strain.

Conversion of KMC's production activity will make it possible to reduce or mitigate negative consequences of winding up mercury production.

In case the existing beneficiation plant is converted into gold concentration plant and its productivity reaches 200 thousand tonnes per year, the number of employees working at the plant will increase by 80-90 people to make 158 employees. The number of employees at GCP with productivity of 500 thousand tonnes of ore per year will be 241 people. The total number of new working places at the existing and new GCPs will be 328. In addition, about 100 people will be required for loading and transportation of ore from the deposits to Aidarken. The total number of new jobs for KMC will be 428, which compensates for reduction of work places resulting from closure of mercury mine and the total number of employees will not be decreased.

Table 2.2

Human potential of KMC

Division/unit	Staff on the payroll	Including engineers
Mine no. 1	275	25
Mine no. 2	140	18
Beneficiation plant	70	9
Metallurgical plant	100	12
Laboratory (including quality control department)	40	
Power engineering shop	100	7
Instrumentation laboratory	10	
Motor transport shop	78	9
Production shop	27	

At least 1,100 new jobs will be created for ore mining at the nearest gold deposits. The employees of KMC can get new jobs, which means that the number of employed people in the settlement will increase reducing the level of unemployment.

Operation of industrial enterprises relies on the use of services provided by some external organizations: railway, power supply, trade etc. This provides indirect employment. Most of the materials (fuel, chemical agents, instrumentation) are supplied from abroad, but human resources are accounted in the indirect employment. Furthermore, induced employment in trade, education, healthcare and agriculture also grows up. Earlier calculations [1] for KMC established that 0.9-1 working places of indirect and induced employment account for one working place of direct employment. In other words, 1,400 new working places in the mines and at GCP will lead to creation of almost the same number of jobs of indirect or induced employment.

Social effect of KMC conversion is not restricted by this factor described above. New motor roads, electricity transmission lines, service points will be built for operation of the mines. This will also improve the living conditions of local population.

2.4 Potential environmental impact of cluster gold concentration plant at KMC

The following potential environmental impact is predicted when making a decision on the use of the existing beneficiation plant of Khaidarkan Mercury Combine and/or about construction of new cluster gold concentration plant (CGCP) at the industrial site of Novaya mine given the use of the existing tailings pond.

The use of the existing beneficiation plant and construction of CGCP does not require assignment of new land plots. Existing industrial sites with developed infrastructure within the current land allotment will be used. This will help avoid additional impact on land resources and will not require additional permits.

As it has been mentioned above, the existing tailings pond is 50% full of its designed capacity level. Its technical condition is satisfactory. Part of the work on dam topping in order to increase its capacity has been carried out. Tailings are in dry condition and are the source of dust (during dry and windy weather). According to the certificate for hydraulic engineering structure (2008), tailings stored in the tailings pond are dump waste in terms of the residual amount of extractable materials in them and cannot be used as a secondary raw material. The condition of the pulp line is unsatisfactory and should be replaced completely.

At present, the tailings pond does not have impervious screen and enclosure. The throughput capacity of the pulp line was designed for the capacity of the existing beneficiation plant. That is why, its further use (loading up to the designed capacity) in case of processing gold-containing ore is possible after implementation of some additional improvement measures:

- creation of impervious screen on top of the dumped tailings and creation of enclosure;
- replacement of the pulp line and auxiliary equipment to ensure throughput of tailings from the concentration plant with productivity of up to 500 thousand tonnes of ore per year.

Gold-containing ore will be delivered from the deposits to the plant by motor transport via new motor road bypassing Sokh Enclave that will link KMC with Altyn-Dzhylga, Duvatash and Chakush deposits.

In operation of the beneficiation plant and CGCP, ore preparation unit and open ore storages are the source of intensive dust emission. Production processes, premises for preparation of process solutions and vessels for their storage are sources of gaseous substances’ emissions. Contemporary process lines at new CGCP should be equipped with up-to-date, highly efficient gas and dust catching installations. Planned modernization of the existing beneficiation plant presupposes installation of gas and dust treatment equipment at the sources of atmospheric pollutants' emission. Reduction of dust emission at open sites will be achieved through intensive damping/sprinkling of the raw material.

Atmospheric pollutions from the existing beneficiation plant with annual productivity of 200 thousand tonnes of ore (after respective modernization) and from the planned CGCP with annual productivity of 500 thousand tonnes of ore will be about 100 tonnes per year (mainly, dust) given the application of dust catchment and gas treatment measures:

Production sites of beneficiation plant and GCP	Specific emissions, t of pollutants/1 t of ore*	Existing beneficiation plant		Planned GCP	
		productivity	pollutant emission, t/year	productivity	pollutant emission, t/year
Ore preparation unit	0.00015	200,000 tonnes of ore per year	30.0	500,000 tonnes of ore per year	75.0
Flotation section, section of chemical agent preparation, chemicals' storage	0.0000005		0.1		0.25
Total			**30.1**		**75.25**

If the mercury production is closed down, it is important to carry out reclamation of the polluted territories to minimize toxic impact of mercury vapour from residual contamination accumulated during the past years on the health of employees and the population in general. This could be partly made at own cost (or at the cost of the state budget, if the enterprise remains under the state control) and partly at the cost of the credit/grant/technical assistance.

Water supply to the plants will be made from the existing water supply systems (possibly, through the use of mine water) with introduction of recycled water supply. Specific water consumption by the concentration plants is 4-5 m^3/1 tonne of ore. Expected average water consumption by the existing beneficiation plant is 1 million m^3/year, by CGCP - 2.25 million m^3/year.

Water with tailings from beneficiation process from the existing beneficiation plant and from the planned CGCP will be fed to the tailings pond and then recycled after sedimentation. As the recycled water supply is planned, no discharge of waste water from the process facilities into the natural environment is expected.

With specific daily water consumption by a person of 100 l/day, the total water consumption at the beneficiation plant for household needs (158 employees) will be 5,372 m^3/year (15.8 m^3/day), and the total water consumption at CGCP (241 employees) will be 8,194 m^3/year (24.1 m^3/day). Household wastewater will be drained into the existing treatment facilities of the settlement.

The amount of the dumped waste will be 99% of the processed ore amount (beneficiation plant – 198,000 tonnes, CGCP – 495,000 tonnes). Chemical composition of waste corresponds to composition of the processed ore with some residual (trace) quantity of the flotation chemicals and sodium cyanide if cyanidation process is applied.

Combined disposal of flotation tailings and cyanidation tailings is planned. Toxic level of cyanidation tailings is reduced if stored together with neutral flotation tailings. Decomposition products of chemical agents delivered to the tailings pond together with the tailings pulp are mostly in liquid phase and after sedimentation and decomposition due to the oxidation from exposure to air and hydrolysis are in very small amounts. Thus, self-cleaning of liquid phase from suspended solids and residual amount of chemicals is observed in the tailings pond. Amount of solid household waste will be 20 tonnes per year.

2.5 Comparative analysis of environmental impacts

Below is a summary of the characteristics of the gold ore deposits planned to be developed and located not far from Aidarken settlement. The environmental impact of developing gold deposits are considered according to two options:

1. Traditional one, with construction of GCPs and tailings ponds at each deposit;

2. Innovative one, with ore processing at the beneficiation plant and CGCP of KMC taking into account the capacity of the existing plant being increased from 100 thousand tonnes to 200 thousand tonnes of ore per year and with construction of a new GCP with a productivity of 0.5 million tonnes of ore per year.

The potential environmental impact for each of the deposits is considered on the basis of the application of similar underground mining schemes, except for the Gavian deposit, where open-cast mining is used. It is assumed that gold ore processing at KMC will involve the tailings dumped into the tailings pond equipped with an impervious screen.

In case of underground mining, disturbance of land and landscape will be observed within limited areas: drift entry platforms, industrial sites, access roads and heaps of barren and side rock (though only a small amount? insufficient amount).

The area of land (400 hectares in total) taken for the hconstruction of GCP, tailings pond and infrastructural facilities will be required in case of concentration plant at each of the deposits.

Fauna in the area of Altyn-Dzhylga, Duva-Tash, Chakush, Aprelskoye deposit' facilities is relatively scanty because of the short distance to populated areas and past and present geological operations. In the case of underground mining in the deposit, the noise impact from mining and transportation equipment and machinery in the drifts will be minor.

Truck transport will move along roads planned to be outside the territory of populated areas thus excluding noise impact on the population. In the event of gold ore processing at CGCP of KMC, ore will be transported from the deposits by heavy vehicles a distance of 30-150 km. In all cases, construction of access and process roads will be required with taking up additional land. Atmospheric emissions from motor transport will be dust from road surface and exhaust gases.

Comparative characteristic of environmental impact by GCPs built at each gold ore deposit and by CGCP of KMC is given in table 3.3.

As it is obvious from the comparative characteristic of the two options of deposits development (individual GCPs and cluster GCP of KMC), investors (private companies working at the deposits) and the government should pay attention to the list of environmental advantages of ore processing at GCP of KMC:

1. There is no need for the construction of GCPs with tailing ponds and infrastructure facilities at each gold ore deposit and thus there is a substantially reduced potential risk of negative impact on the mountain ecosystems, water sources and preservation of pasture lands. In addition, there is no need for, and reduced costs of, land reclamation after the deposit have been developed. Kyrgyzstan has a lot of tailing ponds without any reclamation and the entire load of problems is put on local population and the authorities.
2. Opposition and protests of local population in relation to negative environmental factors will be reduced to a minimum. This is important as in recent years the factor of positive public perception and approval of ore mining facilities construction in Kyrgyzstan has been the basis for permits and conflict-free industrial operations.
3. The GCP of KMC will use the existing tailing pond after appropriate modernization involving construction of an impervious screen, provision of enclosure and monitoring systems, replacement of pulp line to increase its throughput capacity, and the creation of a recycled water supply system. If field studies confirm environmental advisability, the existing waste accumulated in the tailing pond of KMC will be isolated with a screen. This will make it possible to reduce environmental impact and negative impact of dust emission.

4. Water consumption for ore processing will be reduced compared to GPCs establishment at each deposit by more than 1 million m^3/year. This saving will be important as there are already significant water shortages in the densely populated district of the Sokh River.
5. The existing beneficiation plant of KMC does not have a dust and gas treatment system. In the case of gold ore processing at this beneficiation plant, the latter should be subject to modernization with installation of dust and gas treatment equipment. In case of building new a GCP, process scheme with equipment corresponding to up-to-date requirements to dust and gas treatment will be envisaged. In general, ore processing at GCP of KMC will make it possible to reduce atmospheric emissions by 50 tonnes a year (mainly, in the form of dust from the ore preparation process) compared to processing at individual deposits. Having said that up to 40 heavy tipping trucks will have to be used for ore transportation from the deposits to KMC. Their operation will result in atmospheric emissions.
6. The impact on flora and fauna in the area of deposits' development will go down. Impact on fauna will mostly be in the form of noise from operation of mining equipment, accumulation of people and heavy transport machinery.
7. The development of mining and the processing base directly at the deposits will require a large number of high-skilled human resources that are currently not available in the regions with rural population occupied in agriculture. Gold ore processing at GCP of KMC may lead to reduced number of human resources (down by about 300 employees) as here up to 150-200 trained specialists of KMC will be employed.

Table 2.3

Comparative characteristic of environmental impact by GCPs built at each gold ore deposit and by CGCP of KMC

Name of facility	Expected impact on environmental components							Human resources
	on land resources		on water resources		on atmospheric air		on bio-diversity	
	area of assigned lands	amount of waste, t/year	source of water supply, water consumption volume	amount of wastewater discharge into environment	availability of dust and gas treatment facilities	pollutant emission, t/year	status before and after deposit development project	
KMC								
Existing beneficiation plant, 200 thousand t/year	Assignment of land is not required, use of existing processing capacities. Installation of impervious screen at the existing tailings pond is necessary, replacement of pulp line pipes	Beneficiation tailings (flotation and cyanidation) of 198,000 t – to tailings pond with impervious screen. Solid household waste of 8.7 t/year – to the existing authorized dump site	Existing water supply system of KMC, use of mine water is possible, 1 million m^3/year Household water supply 5,372 m^3/year	Discharge of process wastewater into environment is not expected. Discharge of household wastewater into treatment facilities of the settlement	Additional equipping of the existing process line with dust and gas treatment facilities is necessary	Ore preparation unit – 30 t/year (non-organic dust) Flotation sections, chemicals preparation and storage sections – 0.1 t/year (chemicals' vapour)	No impact on bio-diversity is expected	Use of local high-skilled employees, 158 persons, no accommodation provision is required
Projected CGCP, 500 thousand t/year	Assignment of land is not required, use of existing unoccupied industrial sites with infrastructure. Installation of impervious screen at the existing tailings pond is necessary	Beneficiation tailings (flotation and cyanidation) of 495,000 t – to tailings pond with impervious screen. Solid household waste of 13.3 t/year – to the existing authorized dump site	Existing water supply system of KMC, use of mine water is possible, 2.25 million m^3/year Household water supply 8,194 m^3/year	Discharge of process wastewater into environment is not expected. Use of recycling water supply. Discharge of household wastewater into treatment facilities of the settlement	Use of up-to-date process equipment for CGCP with highly efficient dust and gas catching facilities	Ore preparation unit – 75 t/year (non-organic dust) Flotation sections, chemicals preparation and storage sections – 0.25 t/year (chemicals' vapour)	No impact on bio-diversity is expected	Use of local high-skilled employees, 241 persons, no accommodation provision is required
Total:	**Land assignment is not required**	**Beneficiation tailings – 693.000 t/year, SHW – 22 t/year**	**Process water supply 3.25 mln. m^3/year, household water supply – 13,566 m^3/year**	**Discharge of process wastewater into environment is not expected**		**105.35 t/year**	**No impact on bio-diversity is expected**	**399 people**
Gold ore deposits, ore processing at own GCPs								
Altyn-Dzhylga, underground mining, 500 thousand t/year	50 hectares construction of mine facilities, GCP with tailings pond, rotational village,	Beneficiation tailings 499,900 t – to tailings pond with impervious screen. Solid household waste	Source of water supply is the Sokh River. Process water supply to the mine – 80,000	Discharge of wastewater into environment is not expected.	Sprinkling of rock during mining operations, in ore preparation unit, equipping pollutant	Mine – 17.5 t/year; ore preparation unit – 75 t/year; GCP – 0.25 t/year; work of mining and	Disturbance of soil layer and vegetation on an area of 30 hectares; change of habitats on an area of over 50	450 employed persons, recruitment, training, building of the rotational

	infrastructural facilities. Building of motor road – 20-25 ha	of 130 t/year – to own waste landfill Barren rock heap (used for road filling)	m^3/year. Process water supply to GCP – 2,267,000 m^3/year. Household water supply 15,300 m^3/year	Use of recycling water supply.	emission sources of GCP with dust and gas treatment facilities	transportation machinery – 34 t/year	hectares	village with infrastructure
Chakush underground mining, GCP, 200 thousand t/year	100 hectares construction of mine facilities, GCP with tailings pond, rotational village, motor road (36.6 hectares), infrastructural facilities	Beneficiation tailings 191,000 t – to tailings pond with impervious screen. Solid household waste of 102 t/year – to own waste landfill. Barren rock heap (used for road filling)	Source of water supply is the Sokh River. Process water supply to the mine – 32,000 m^3/year. Process water supply to GCP – 620,000 m^3/year. Household water supply 9,042 m^3/year	Discharge of wastewater into environment is not expected. Use of recycling water supply.	Sprinkling of rock during mining operations, in ore preparation unit, equipping pollutant emission sources of GCP with dust and gas treatment facilities	Mine – 7.0 t/year; ore preparation unit – 30 t/year; GCP – 0.1 t/year; work of mining and transportation machinery – 14 t/year	Disturbance of soil layer and vegetation on an area of 40 hectares; change of fauna habitats on an area of over 100 hectares	350 employed persons, recruitment, training, building of the rotational village with infrastructure
Duva-Tash underground mining, GCP, 150 thousand t/year	60 hectares construction of mine facilities, GCP with tailings pond, rotational village, infrastructural facilities	Beneficiation tailings 148,500 t – to tailings pond with impervious screen. Solid household waste of 58 t/year – to own waste landfill. Barren rock heap (used for road filling)	Source of water supply – the Sokh River. Process water supply: to the mine - 24,000 m^3/year. to GCP – 675,000 m^3/year. Household water supply 6,800 m^3/year	Discharge of wastewater into environment is not expected. Use of recycling water supply.	Sprinkling of rock during mining operations, in ore preparation unit, equipping pollutant emission sources of GCP with dust and gas treatment facilities	Mine – 5.25 t/year; ore preparation unit – 22.5 t/year; GCP – 0.08 t/year; work of mining and transportation machinery – 10 t/year	Disturbance of soil layer and vegetation on an area of 40 hectares; change of fauna habitats on an area of over 60 hectares	200 employed persons, recruitment, training, building of the rotational village with infrastructure
Gavian, open-cast mining, GCP, 50 thousand t/year	100 ha, pit, construction of mining facilities, GCP with tailings pond, rotational village, 15 km access road (30 ha), infrastructural facilities	Heap of overburden rock 420,000 t/year Beneficiation tailings 49,500 t – to tailings pond with impervious screen. Solid household waste of 29 t/year – to the existing authorized dump site of Aidarken village.	Source of water supply is the Gauyan River. Process water supply to the pit – 8,500 m^3/year. Process water supply to GCP – 225,000 m^3/year. Household water supply	Discharge of wastewater into environment is not expected. Use of recycling water supply.	Sprinkling of rock during mining operations, in ore preparation unit, equipping pollutant emission sources of GCP with dust and gas treatment facilities	Pit – 12.5 t/year; ore preparation unit – 7.5 t/year; GCP – 0.025 t/year; work of mining and transportation machinery – 7 t/year	Disturbance of soil layer and vegetation of alpine and sub-alpine meadows, high mountain pastures on an area of 100 hectares; cutting of trees and bushes (sometimes, red-mantled forest) is necessary; change of	100 employed persons, use of professional human resources of KMC, building of the rotational village with infrastructure

			3,400 m^3/year				fauna habitats on an area of over 100 hectares	
Aprelskoye, underground mining, GCP, 150 thousand t/year	100 hectares construction of mine facilities, GCP with tailings pond, rotational village, infrastructural facilities	Beneficiation tailings 138,000 t – to tailings pond with impervious screen. Solid household waste of 58 t/year – to own waste landfill. Barren rock heap (used for road filling)	Source of process water supply is the Leylek River, source of drinking water supply is the Almaly River. Process water supply to the mine – 24,000 m^3/year. Process water supply to GCP – 720,000 m^3/year. Household water supply 6,800 m^3/year	Discharge of wastewater into environment is not expected. Use of recycling water supply (640,000 m^3/year)	Sprinkling of rock during mining operations, in ore preparation unit, equipping pollutant emission sources of GCP with dust and gas treatment facilities	Mine – 5.25 t/year; ore preparation unit – 22.5 t/year; GCP – 0.075 t/year; work of mining and transportation machinery – 10 t/year	Disturbance of soil layer and vegetation on an area of 70 hectares; change of fauna habitats on an area of over 100 hectares	200 employed persons, recruitment, training, building of the rotational village with infrastructure
Total	Assignment of land for construction of GCPs will be necessary at each deposit to a total area of 400 ha	Amount of dumped beneficiation tailings in 5 tailings ponds will be 1,026,900 t/year. Generation of SHW will be 377 t/year; 348 t of that total amount will be disposed of at own waste landfills; assignment of at least 12 ha of land will be required. (for 4 deposits)	Source of water supply – Sokh, Liaylak, Gauyan Rivers. The total water supply of the mines and the pit is 168,500 m^3/year, that of GCP is 4,507,000 m^3/year. Household water supply - 41,342 m^3/year	Discharge of wastewater into environment is not expected. Use of recycling water supply at GCP: 70% - recycling water supply – 3,155,000 m^3/year, 30% clean water – 1,352,000 m^3/year	Sprinkling of rock during mining operations, in ore preparation unit, equipping pollutant emission sources of GCP with dust and gas treatment facilities is envisaged at all GCPs	The total atmospheric emissions will be: from mining operations – 47.5 t/year; from the work of mining and transportation machinery – 75 t/year; from ore preparation units – 157.5 t/year; from GCPs – 0.53 t/year	Disturbance of soil layer and vegetation on an area of about 280 hectares is observed; area of impact on fauna is over 400 hectares	Recruitment of about 1,300 employees will be necessary of which 700-800 people will require training and skill conversion. Construction of rotational villages with infrastructure will be necessary for 1,300 people
Gold ore deposits, ore processing at the cluster gold concentration plant of KMC								
Altyn-Dzhylga, underground mining, ore transportation to CGCP of KMC (50 km)	25 ha construction of mine facilities, rotational village, infrastructural facilities. Building of motor road – 20-25 ha	Solid household waste of 65 t/year – to own waste landfill. Barren rock heap (minor volume to be used for road filling)	Source of water supply is the Sokh River. Process water supply to the mine – 80,000 m^3/year. Household water supply 7,650 m^3/year	Discharge of wastewater into environment is not expected.	Sprinkling of rock during mining operations, sprinkling of roads during ore transportation	Mine – 17.5 t/year. Work of mining and transportation machinery – 34 t/year. Motor transport (17 tipping trucks of 30 t each) – 77 t/year	Disturbance of soil layer and vegetation; change of fauna habitats on an area of over 25 hectares	200 employed persons, recruitment, training, building of the rotational village with infrastructure
Chakush,	80 ha construction of	Solid household	Source of water	Discharge of	Sprinkling of rock	Mine – 7.0 t/year.	Disturbance of soil	170 employed

underground mining, ore transportation to CGCP of KMC (55 km)	mine facilities, rotational village, building of motor road (including 36.6 ha), infrastructural facilities	waste of 51 t/year – to own waste landfill. Barren rock heap (minor volume to be used for road filling)	supply is the Sokh River. Process water supply to the mine – 32,000 m^3/year. Household water supply 4,521 m^3/year	wastewater into environment is not expected.	during mining operations, sprinkling of roads during ore transportation	Work of mining and transportation machinery – 14 t/year. Motor transport (7 tipping trucks of 30 t each) – 34 t/year	layer and vegetation; change of fauna habitats on an area of over 80 hectares	persons, recruitment, training, building of the rotational village with infrastructure
Duva-Tash, underground mining, ore transportation to CGCP of KMC (30 km)	40 ha construction of mine facilities, rotational village, infrastructural facilities	Solid household waste of 29 t/year – to own waste landfill. Barren rock heap (minor volume to be used for road filling)	Source of water supply is the Sokh River. Process water supply to the mine – 24,000 m^3/year. Household water supply 3,400 m^3/year	Discharge of wastewater into environment is not expected.	Sprinkling of rock during mining operations, sprinkling of roads during ore transportation	Mine – 5.25 t/year. Work of mining and transportation machinery – 10 t/year. Motor transport (4 tipping trucks of 30 t each) – 15.4 t/year	Disturbance of soil layer and vegetation; change of fauna habitats on an area of over 40 hectares	90 employed persons, recruitment, training, building of the rotational village with infrastructure
Gavian, open-cast, ore transportation to CGCP of KMC (25 km)	80 ha, pit, construction of mining facilities, rotational village, 15 km access road (including 30 ha), infrastructural facilities	Heap of overburden rock 420,000 t/year Solid household waste – 15 t/year – to authorized dump site of Aidarken settlement	Source of water supply is the Gauyan River. Process water supply to the pit – 8,500 m^3/year. Household water supply 1,700 m^3/year	Discharge of wastewater into environment is not expected.	Sprinkling of rock during mining operations, sprinkling of roads during ore transportation	Pit – 12.5 t/year. Work of mining and transportation machinery – 7 t/year. Motor transport (2 tipping trucks of 30 t each) – 4 t/year	Disturbance of soil layer and vegetation of alpine and sub-alpine meadows, high mountain pastures on an area of at least 80 hectares; cutting of trees and bushes (sometimes, red-mantled forest) is necessary at construction sites. Change of fauna habitats on an area of over 80 hectares	60 employed persons, use of professional human resources of KMC, building of the rotational village with infrastructure
Aprelskoye, underground mining, ore transportation to CGCP of KMC (180 km)	80 ha construction of mine facilities, rotational village, infrastructural facilities	Solid household waste of 29 t/year – to own waste landfill. Barren rock heap (minor volume to be used for road filling)	Source of process water supply is the Leylek River, source of drinking water supply is the Almaly River. Process water supply to the mine – 24,000 m^3/year. Household water supply 3,400 m^3/year	Discharge of wastewater into environment is not expected.	Sprinkling of rock during mining operations, sprinkling of roads during ore transportation	Mine – 5.25 t/year. Work of mining and transportation machinery – 10 t/year. Motor transport (8 tipping trucks of 30 t each) – 76 t/year	Disturbance of soil layer and vegetation; change of fauna habitats on an area of over 80 hectares	90 employed persons, recruitment, training, building of the rotational village with infrastructure

Total	Assignment of land for construction of mining facilities at each deposit will ne necessary to a total area of 300 ha	Amount of dumped beneficiation tailings in one existing tailings pond of KMC will be 198,000 t/year (existing beneficiation plant - 200,000 t/year) or 495,000 t/year (projected CGCP – 500,000 t/year)	Source of water supply – Sokh, Liaylak, Gauyan Rivers. The total water supply of the mines and the pit is 168,500 m^3/year. Household water supply - 20,671 m^3/year. Process water supply to the beneficiation plant and GCP of KMC – 3,250,000 m^3/year, household water supply to beneficiation plant and GCP of KMC – 13,566 m^3/year	Discharge of wastewater into environment is not expected. Water used for sprinkling (dust suppression) in mining operations and during transportation – irrecoverable losses	Sprinkling of rock during mining operations and ore transportation is envisaged at all deposits	The total atmospheric emissions will be: from mining operations – 47.5 t/year; from the work of mining and transportation machinery – 75 t/year from work of motor transport (38 vehicles) – 206.4 t/year. Beneficiation plant and GCP of KMC – 105.35 t/year **Total of 434.25 t/year**	Disturbance of soil layer and vegetation on an area of about 100 hectares is observed; area of impact on fauna is over 300 hectares	Recruitment of about 600-650 employees will be necessary for mining operations, of which 300-350 people will require training and skill conversion. Construction of rotational villages with infrastructure will be necessary for 650 people. Beneficiation plant and GCP of KMC – 400 people
Advantages of ore processing at the existing beneficiation plant and at the contemplated CGCP of KMC									
	Reduced need for assignment of pasture land for construction of GCP facilities at each deposit to a total area of 100 ha, number of tailings ponds reduced from 5 (all gold ore deposits) to 1 (at CGCP of KMC)	Amount of gold ore beneficiation tailings will reduce by about 334,000 t/year. Amount of solid household waste will reduce by 177 t on average	Water consumption for ore processing will reduce by 1,257,000 m^3 /year, (including consumption of clean water – 880,000 m^3/year). Household water consumption will reduce by 7,105 m^3/year	Discharge of wastewater into environment is not expected in both ore processing options.	Equipping of one GCP with a set of highly efficient dust and gas treatment equipment rather than 5 GCPs at each deposit	Total atmospheric emissions from ore processing will reduce by 53 t/year when operating beneficiation plant and GCP at KMC. Yet, atmospheric emissions from motor transport delivering ore from the deposits to the beneficiation plant and GCP of KMC will grow up by 206.4 t/year	Disturbance of soil layer and vegetation will reduce by about 200 ha, area of impact on fauna will decrease by 100 hectares	Operation of CGCP will demand recruitment of smaller number of unskilled employees (300 people less); high-skilled employees of KMC will be employed (150-200 people), including those temporarily unemployed; reduction of cost for training

2.6 Payments for the use of natural resources and environmental pollution

To promote environmental protection and efficient use of natural resources in the Kyrgyz Republic a regulation on environmental payments was adopted. It includes:

- *Payment for land*
- *Payment for mineral resources*
- *Payment for subsurface use*

The form of payments: one off payment and then subsequent regular payments in the course of mining.

Payment for environmental pollution is a form of compensation for economic damage caused by emission of pollutants into the atmosphere, discharge of wastewater and disposal of production and consumption waste.

According to the legislation of the Kyrgyz Republic, the rate of payment for environmental pollution (emission of atmospheric pollutants, discharge of wastewater, waste disposal) is 1.2 KGS per one tonne equivalent of pollutants.

The size of payment depends on the coefficients of the environmental situation and environmental relevance of atmospheric air, state of water resources, and place of waste disposal at the location of industrial facility.

In calculating payment for atmospheric emissions, the coefficient of environmental situation and environmental relevance may vary from 80 (for Aidarken) to 12 (if a facility is located in mountainous area).

The coefficient of the environmental situation and environmental relevance in calculating the of payments for discharge of wastewater into the environment varies from 100 to 300 depending on the category of water body or territory where wastewater is discharged.

The coefficient of the environmental situation and environmental relevance in calculating the payments for solid waste disposal varies from 1 to 40 depending on the status of the place of waste disposal and distance to the nearest populated area. If waste is disposed to landfills, slurry pits and other specially equipped facilities, and the rules of environmentally safe conditions of waste storage and disposal are observed and the required regulatory and technical documentation provided then a 0.3 reduction coefficient to the payment rate is applied.

Table 2.4.

Comparative review of payments for environmental pollution

Deposit	Payments for environmental pollution, thousand KGS/year		
	Ore mining and processing by own GCPs	Ore processing at CGCP of KMC	
		Ore mining and transportation	Beneficiation
Altyn-Dzhylga	5,429	59	
Chakush	2,076	26	
Duva-Tash	1,613	14	
Gavian	4,315	3,785	
Aprelskoye	1,500	47	
Total:	**14,933**	**3,931**	
Existing beneficiation plant	-		2,168
Contemplated GCP			5,419
Sub-total		**3,931**	**7,587**
Total:	**14,9**	**11,5**	

It is obvious from the comparative characteristics in the table above that, the total payments for environmental pollution (for all the deposits) when processing ore by individual mine GCPs totals 14.9 million KGS/year. In case of ore processing in Aidarken settlement, total payments 11.5 million KGS/year, which is 3.4 million KGS less. The damage caused to the environment by mining and processing facilities are also lower.

3. Mineral resources base in the area of Khaidarkan Mercury Combine and opportunities to develop production of alternative raw materials

In terms of diversity and concentration of mineral resources, as well as their commercial relevance, the Batken region, where Khaidarkan Mercury Combine (KMC) is located, occupies the leading place in the Kyrgyz Republic. For many decades this region has been producing oil, natural gas, coal, antimony, mercury, fluorite, as well as raw materials for production of glass, cement, agloporite, refractory and building bricks. The region has built up a substantial workforce capacity consisting of mining professions and established its own production practices. The Khaidarkan mercury deposit and Kadamzhay antimony deposit have global importance in terms of the reserves of these specific metals There is a huge unexplored potential of gold, tantalum, niobium, aluminium, mineral pigment and gypsum deposits. These offer various opportunities for conversion of the mercury plant within the framework of the mining industry.

Commercially, mercury has been produced in Khaidarkan since 1941. To the present day, the Combine continues the development of mercury deposits – the Khaidarkan and Novoye (New) deposits. These deposits totalled 18 million tonnes of ore and have accounted for the production of 29 thousand tonnes of mercury. The remaining mercury reserves in these and other deposits of the Batken region amount to 29 thousand tonnes. Mercury ore is processed at KMC without concentration in the iron and steel plant's furnaces and with 90-92% of the mercury being extracted. Earlier, complex mercury-antimonic-fluorite ore with low content of mercury (0.02-0.04%), antimony (0.3-0.8%) and fluorite was delivered to the beneficiation plant for production of mercury-antimonic and fluorite concentrates. The Mercury-antimonic concentrate was subject to burning and after mercury extraction was sent to the Kadamzhay antimony plant. The fluorite concentrate was exported. Today, the beneficiation plant is out of operation.

Taking into account the international agreement (convention) that is being developed within the framework of UNEP, which envisages the termination of primary mercury mining and production, implementation of a number of projects on processing of other mineral resources in addition to the prospects of gold mining and concentration for KMC's conversion are considered below.

The following deposits were chosen out of many dozens of various mineral deposits as the most attractive ones for business and mining using the KMC's potential in order to replace mercury production with other economically and environmentally acceptable types of mining industry processes.

3.1 Deposits of aluminium

Nephelinic syenite deposits under common name Zardalekskoye consists of three separate deposits located on the right side of the mountain chain, in the middle reaches of the Sokh River, 1,800-3,200 m above sea level. The deposit is 35 to 40 km to the south-east of KMC. The closest railway station, Isfara, is 80 km away from the deposit. The lower parts of the deposit are linked to the motor road along the valley of the Sokh River by means of 5 km long technological road. The district represents a well developed area. The content of nepheline is up to 70%. The explored sites for initial development are:

- Nizhnee (Al_2O_3 content - 22%, silica modulus – 3.8, reserves (C_1+C_2) - 20 million tonnes);
- Yuzhnoye (Al_2O_3 content - 22%, silica modulus – 3.8, reserves (C_1) - 54 million tonnes);
- Molodost (Al_2O_3 content - 22%, silica modulus – 3.9, reserves (C_1) - 50 million tonnes).

The ores were proof tested. The location of the carbonate raw material deposits, fluorspar and coal deposits in the region and prospects for expansion of nephelinic syenite reserves by means of the nearest deposits makes this object more attractive. The predicted resources of aluminium oxide are estimated at 4 billion tonnes. Given the availability of raw materials, the key factor in the future development of the aluminium industry is development of national hydropower potential.

The Russian Company jointly with Kyrgyz experts have arranged a preliminary technical feasibility and economic study to establish an aluminium and power complex that can become the basis for industrial and economic development of Batken region. On the basis of the published information, a feasibility study for development of nephelinic syenite deposit is being prepared. The initial estimation of the capital expenditure is USD 5 billion.

3.2 Non-metallic mineral resources

Magnesite. Magnesium carbonate is used for the production of refractory materials that can withstand temperatures of up to 2,800 ºC and are resistant to corrosive environments. Materials prouced using this include bricks, special sorts of cement, abrasive materials, fireproof paints.

Productive mineralization is concentrated in serpentine rocks that are refractory material on their own. The size of the area containing magnesite is 3,000 m×300-500 m×10-12 m. Magnesite content in the ore is up to 45%. Magnesite reserves of C_1 category are estimated to be 31 thousand tonnes, predicted resources of P_1 category are 200 thousand tonnes with an average magnesite content of 10%; 17 thousand tonnes of magnesite are accounted in the state balance under C_1 category.

Deposits of serpentinite, gypsum and bentonite clay have been considered as possible sites for the use of production capacities and workforce of KMC. Besides, near KMC there are talcum deposits with commercial reserves of 1.4 million tonnes and deposits of natural silicon oxide suitable for production of semi-conductors, semi-precious and ornamental stones such as nephrite and rodingite.

3.2.1 Kanskoye serpentinite deposit

The production of serpentinite ore is necessary to meet the demand for refractory materials from enterprises located in Ferganskaya Valley and other consumers.

The Kanskoye deposit is located on the edge of Kan settlement, in the Kadamzhay district of Batken region, between the Sokh and Shakhimardan Rivers, 30 km north of Aidarken settlement, 1,000-1,300 m above the sea level. It is linked to the settlement by 100 km motor road. The deposit has been developed since 1950s. The length of the productive body is 8 km, while its width is 2 km and vertical extent is 400 m. The content of magnesium oxide is 36%. Measured reserves of serpentinite under C_2 category are 21.0 million tonnes or 7 million tonnes in magnesium oxide equivalent. Reserve increment is not limited.

Mining and technical conditions as well as the peculiarities of geological structure predetermine result in open-cast mining. Five million tonnes of serpentinite have been taken for intended development. The productivity of the pit is 240 thousand tonnes of ore per year. The amount of reserves is sufficient for more than 20 years. There is a possibility of creating 21 new jobs, including 14 employees in the pit and 7 persons working at crushing-and-screening plant.

The productivity of the pit will depend on the level of demand for the product. Today, potential consumers of refractory materials are: Yuzhno-Kyrgyzskiy Cement, the Aravanskiy Cement Plant, the Bekabad Iron and Steel Plant, Kuvasayskiy Glass Works and the Almalykskiy Cement Plant.

The need of capital expenditure has been determined on the basis of the intended production volume, required mining and process equipment and cost of constructing the general engineering infrastructure. The calculation has been also based on the data of similar projects. The total cost of the project is 1.2 million USD.
Operational expenditure includes the costs for mining of serpentinites, crushing, as well as general and administrative costs. General and administrative costs are assumed to be 5% of the mining costs. Full product cost includes operational expenditures, depreciation, land reclamation costs, taxes and deductions.

Table 1.1 shows average annual cost of serpentinite mining and transportation and table 1.2 provides the key technical and economic indicators.

As follows from the table below, the work of the pit is profitable (generating 995 thousand USD) if the cost of serpentinite mining without transportation is 8.22 USD per tonne and its market price is USD 12.83. The inclusion of transport cost leads to reduction of profit. That is why delivery of the products to the consumer market should be taken into account when planning the project to produce refractory materials in situ using the infrastructure and human resources of Kan settlement.

Table 3.1

Average annual cost of serpentinite production

Cost item	Amount of annual costs		
	Total annual expenses, Thousand USD	Per 1 tonne of ore, USD	Per 1 m3 of ore, USD
Operational expenditures			
Mining operations			
Ore mining	673,608	2.81	7.02
Mining operations, total	**673,608**	**2.81**	**7.02**
Crushing, sorting	417,600	1.74	4.35
General and administrative costs (5%)	174,560	0.73	1.82
Other unforeseen costs	183,288	0.76	1.91
Total for the production site	**1,449,056**	**6.04**	**15.09**
Depreciation	160,631	0.67	1.67
Reclamation	40,097	0.17	0.42
Taxes and deductions, total:	161,991	0.67	1.69
including:			
royalty (2%)	80,996	0.34	0.84
sales tax (2%)	80,996	0.34	0.84
Full cost, total	**1,973,767**	**8.22**	**20.56**

Table 3.2

Key technical and economic indicators of serpentinite production at Kanskoye deposit

#	Indicator	Meas. unit	Values
1	Annual production capacity	Thousand m^3	96.0
		Thousand tonnes	240.0
2	Number of employees, total	persons	21
	including:		
	production employees	persons	17
	managers, specialists	persons	4
	Amount of capital expenditures, total	USD thousand	1,200
3	**Annual operational expenditures**	**USD thousand**	**1,974**
	including:		
	Mining	USD thousand	674
	Crushing and sorting	USD thousand	418
	General and administrative costs (5%)	USD thousand	175
	Other unforeseen costs	USD thousand	183
	Total for the production site	USD thousand	**1,449**
	Depreciation	USD thousand	161
	Reclamation	USD thousand	40
	Taxes and deductions, total:	USD thousand	162
4	**Cost of mining 1 tonne of serpentinites**	**$**	**8.22**
	1 m3	**$**	**20.5**

5	Serpentinite sale price	$/t	12.83
		$/m3	57.03
6	Annual sales proceeds	USD thousand	3,079
7	Annual taxable income	USD thousand	1,106
8	Income tax (10%)	USD thousand	111
9	Net profit	USD thousand	995

Nadirskoye deposit of facing stones is located in Kadamzhay district, 15 km to the north of KMC, 2,180-2,250 m above the sea level. The thickness of the picrite field is 150 – 200 m. Its length is 4.5 km. Three blocks have been singled out with the following parameters: 700×600 m, 60×330 m and 100×800 m. The colour of the rock is saturated black and the stones are characterized by high decorative properties. The rock is suitable for sawing and mirror polishing. Judging by natural stripping, the predicted resources of facing picrites in P_2 category are estimated to be 2.75 million m^3.

Dekabrskoye deposit of bowenite and nephrite is located 25 km north of KMC, 700-1,300 m above the sea level, in the economically developed district. The produced nephrites are compact, easily cuttable and polishable. In the treated form, the stone has grey-green and dark-green colour. Stones are characterized by high decorative properties. Predicted resources are estimated to be over 1 thousand tonnes. Nearby, there are occurrences of various precious and ornamental stones including diopside, agate-like chalcedony, agate and rodingite.

The two deposits can be developed using the potential of KMC as additional sources of profit in the course of the plant's conversion.

3.2.2 Kanskoye gypsum deposit

Kanskoye gypsum deposit. There is a stripe of gypsum sediments encompassing a number of different-scale deposits that goes across Batken region and along the border of Uzbekistan and Tajikistan. Kanskoye deposit is the closest to Aidarken settlement. It is located 30 km away from the settlement and is separated from it by Eshme mountains that are not crossed by any motor roads. The distance between the deposit and the settlement via the existing roads is 100 km. 3 km to the south of the deposit there is Kan settlement built for development of lead ore (the mine is closed).

Asphalted road links the settlement to Kadamzhay-Batken highway that is being under construction. The distance to the highway is about 20 km. The deposit is located near the motor road and 10 kV and 35 kV electricity transmission lines.

30 m thick seam of clean, crystallized gypsum stretches for 2 km. The gypsum content is up to 99%. The predicted resources of P_1 category are 1.8 million tonnes. Gypsum is suitable for any purposes including medical materials. The deposit consists of two blocks.

Reserves of gypsum in block no. 1 are 1.478 million tonnes. The 34-49 m thick seam of gypsum lies at the angle of 40-45º and stretches for a distance of 500 m. The overburden ratio is 0.18 m^3/t. There is no vegetation and soil. The seam goes out onto the surface. The gypsum content is 85-90%.

The second block is 5 km to the north. In its western part, gypsum was mined in 1960-70. The average gypsum content is 99%. The seam thickness is 40-45 m. In terms of quality, the raw material meets the requirements for production of cementing materials, cement, gypsum board. Reserves and resources in C_2+P_1 categories are 10 million tonnes.

In terms of mining and technical conditions both blocks are suitable for open-cast mining. Licenses for the development of both blocks belongs to ANTCo LLC that does not have the resources to finance the work.

The reserves of the two blocks given the total annual production of 100 thousand tonnes are sufficient for over 100 years.

KMC can produce construction gypsum using rotating iron and steel furnaces. Yet, taking into account the transportation costs, the preferred option would be to organize production of construction mixtures, gypsum boards, crest slabs in Kan settlement using the buildings of the former beneficiation plant.

The cost of the capital expenditures is 1.1 million USD. The operational expenditures include costs for production, crushing and sorting of gypsum, manufacture of gypsum boards as well as general and administrative costs. The number of employees according to the staffing list is 21 persons. The cost of materials is calculated on the basis of the annual consumption and market prices valid on the territory of the Kyrgyz Republic in 2011. The manufacturing cost of gypsum boards and crushed gypsum are taken by analogy with the existing manufacture by Mega Union in Dzhalalabad region. The calculations are given in tables 1.3 and 1.4 below.

The cost of production without transportation expenses amounted to 23.5 USD per one tonne of product, while the current local price is USD 20. Thus, raw material production may not be profitable in the current local market conditions.

Table 3.3

Annual cost of gypsum production, processing and transportation

Cost item	Amount of annual costs		
	Total annual expenses, thousand USD	Per 1 tonne of gypsum, $	Per 1 m3 of gypsum, $
Operational expenditures			
Mining of gypsum	669,798	6.70	15.20
Processing of gypsum	1,053,845	10.54	23.92
General and administrative expenses (5%)	136,182	1.36	3.09
Other unforeseen costs	142,991	1.43	3.25
Total for the production site	**2,002,816**	**20.03**	**58.16**
Depreciation	70,933	0.71	1.61
Reclamation	30,737	0.31	0.70
Taxes and deductions, total:	248,359	2.48	5.64
including: *royalty (6%)* *sale tax (2.0%)*	 186,269 62,090	 1.86 0.62	 4.23 1.41
Full production cost, total	**2,352,846**	**23.53**	**66.11**

Table 3.4

Key technical and economic indicators of gypsum mining and transportation at Kanskoye deposit

#	Indicator	Meas. unit	Values
1	Annual production capacity	thousand m^3 thousand tonnes	44,1 100
2	Enterprise operation mode: - working days per year - number of shifts per day - shift duration	 day shift hour	 254 1 8

3	Number of employees, total including: *production employees* *managers, specialists*	persons persons persons	29 26 3
4	Capital expenditures	thousand USD	1,111
5	Annual operational expenditures including: Mining Gypsum processing General and administrative costs (5%) Other unforeseen costs Total for the production site Depreciation Reclamation Taxes and deductions, total:	thousand USD. thousand USD thousand USD thousand USD thousand USD thousand USD thousand USD thousand USD thousand USD	**3,353** 670 1,054 136 143 **2,003** 71 31 248
6	**Production cost of 1 t of gypsum**	**$**	**23,53**
	1 m3	**$**	**66,11**
7	Gypsum sale price (market prices)	$/m3 $/m3	20,00 45.4
8	Annual sale revenue	thousand USD	2,000
9	Annual taxable income	thousand USD	-353
10	Income tax (10%)	thousand USD	
11	Net profit	thousand USD	-353

3.2.3 Bentonite clay

The market price of bentonite clay depending on its quality and designation varies from 20 to 120 USD per one tonne. Bentonite clays in natural state or after activation are good sorbing agents and can be applied for refining of petroleum products, oils and wines. In agriculture, bentonite clays can also be used as a fertilizer, to improve the structure of sandy soils and reduce the quantity of water for irrigation, which is important for the southern part of Kyrgyzstan. Earlier bentonites were mined for production of drilling muds. Currently, the demand for bentonite grows in parallel with the growth of drilling for oil production. Besides, bentonite can be used for reclamation of tailings ponds and cinder resulting from mercury production.

The main deposits of bentonite clays are concentrated in the low-hill, accessible and economically developed parts of Layliak and Batken districts where three deposits are found: Beshkenskoye, Kyzyl-Utek and Ak-Turpak.

Beshkenskoye deposit is the one that has been explored most. It was developed in the period between 1969 and 1977. The deposit is located in Layliak district, 8 km to the north of Margun village, 1,350-1,450 m above the sea level. The productive seam of bentonite clays has a thickness of 5-20 m and length of 820 m. Technological testing established suitability of clay for preparation of drill mud. Commercial reserves of clay in the Western block of the deposit in A+B+C_1 categories are 587 thousand tonnes; non-commercial reserves are 809 thousand tonnes.

Kyzyl-Utek deposit is more significant in size. It is located in in Batken district and is 5 km from Shurab railway station and 90 km from KMC. Here, at the area of 9 km along the strike 6 horizons of bentonitic clay of various quality have been explored. Horizons no. 2 and 6 are formed of clay suitable for preparation of drill mud when drilling under the conditions of salty aggressive environment. Clays of horizons no. 1 and no. 4 can be used to prepare usual drill mud and clays of horizon no. 3 possess good sorption properties. The total predicted reserves to a depth of 10 m are estimated at 10 million tonnes. Mining, technical, hydrological, geological conditions as well as transportation and economic conditions are favourable, but the deposit has not been developed until today.

Proceeding from the geological characteristic of bentonitic clay deposits they can be mined by open-cast method in an amount of 50 thousand tonnes/year with low overburden ratio.

Taking into account small production volume the operation mode is chosen to be five days a week, one shift, 10 persons in total. The required capital expenditures are estimated to be 0.5 million USD.

Table 1.5. shows the average annual cost of bentonite production and table 1.6 gives the main technical and economic indicators for production of bentonite clay from Kyzyl-Utek deposit. Kyzyl-Utek deposit is chosen for consideration as a larger one and located closer to possible consumers in the southern part of the Kyrgyz Republic. As follows from the table on the key technical and economic indicators, even with the product price close to the world minimum (20$/t) and transportation of raw clay to a distance of 5 km by motor transport to Shurab railway station, mining of bentonitic clay is a profitable project.

Table 3.5

Average annual cost of bentonite mining

Cost item	Amount of annual expenses	
	Total, USD	Per 1 t, USD
Operational expenditures		
Mining operations		
Production of bentonites	120,964	2.42
Mining operations, total	**120,964**	**2.42**
Transportation to Shurab railway station (5 km)	25,000	0.50
Processing	217,500	4.35
General and administrative costs (5%)	39,423	0.79
Other unforeseen costs	41,394	0.83
Total for the production site	**444,281**	**8.89**
Depreciation	22,622	0.45
Reclamation	8,919	0.18
Taxes and deductions, total:	36,032	0.72
including:		
Royalty (2%)	*18,016*	*0.36*
Sale tax (2.0%)	*18,016*	*0.36*
Total production cost	**547,886**	**10.96**

Table 3.6

Key technical and economic indicators of bentonitic clay production at Kyzyl-Utek

#	Indicator	Meas. unit	Values
1	Annual production capacity	Thousand tonnes	50
2	Operation mode of the enterprise: - working days per year - number of shifts per day - shift duration	 day shift hour	 305 1 8

3	Number of employees, total including: *production workers* *managers, specialists*	person persons persons	8 7 1
4	Capital expenditures, total	thousand USD	560.00
5	Annual operational expenditures including: Mining of materials Transportation to Shurab railway station (5 km) Processing General and administrative costs (5%) Other unforeseen costs **Total for the production site** Depreciation Reclamation Taxes and deductions	thousand USD thousand USD thousand USD thousand USD thousand USD thousand USD thousand USD thousand USD thousand USD thousand USD	936.85 120.96 25.00 217.50 39.42 41.39 **444.28** 22.62 8.92 36.03
6	**Production cost of 1 t of bentonite**	**$**	**10.96**
7	Bentonite sale price	$/t	20.00
8	Annual sales revenue	thousand USD	1,000
9	Annual taxable income	thousand USD	452
10	Income tax (10%)	thousand USD	45.2
11	Net profit	thousand USD	406.8

4. Conclusions

As of February 2012, the Khaidarkan Mercury Joint Stock Company (KMJSC) was a state-run enterprise. The Khaidarkan Mercury Combine (KMC) sees its future in the development of the lower levels of Khaidarkan's mineral deposits with complex ore reserves in excess of 3.5 million tonnes containing fluorspar and cinnabar. The Khaidarkan Mercury Combine continues to mine primary mercury at the rate of 100-150 tonnes a year. The state support to the industry continues, including subsidies for geological exploration and favourable electricity tariffs for pumping water from the mine. Phasing out mercury production at KMC without alternative development options may have an adverse effect on the life of the local population and on the servicing of local infrastructure linked to the mercury combine. The management of the enterprise is firmly opposed to closure and lobbies the Government against it.

This study shows that the gold deposits and other non-mercury minerals located near Aidarken not only make it possible to replace mercury production cost-effectively, but also to create new jobs. Thus the conclusions of the earlier study by the Kyrgyz Mining Association on the possible options for the mercury combine's redirection- are confirmed. But intensive negotiations and capacity building for all stakeholders (local community, state bodies and private mining sector/operators) and development of the financial mechanisms to change the plant's business profile are necessary in order to achieve further results.

Non-metallic minerals around Khaidarkan, which could be extracted, processed and sold on the local and regional markets, include bentonite, serpentinite, gypsum, facing stones. Up to 50 people from Khaidarkan's total workforce could be involved in mining and processing these minerals. The capital investment needed for each reviewed option varies from USD 0.5 million to 1 million, which is modest compared to the investment required for geological exploration and industrial development of nearby gold deposits (where investment needs range from USD 60 million to 100 million). While the proportion of jobs that could be created through non-metallic mineral mining cannot fully replace Khaidarkan's current workforce of more than 500 people, this kind of mining activity is not necessarily reliant on multinational companies and has fewer environmental impacts and therefore could support a healthier, more resilient community. Aluminium production is also promising - but this is a long-term prospect linked to hydropower development and strategic industrial priorities as well as railway/cross-border relations/international trade conditions.

According to the calculations, the most economically and environmentally reasonable option is to set up a cluster gold concentration plant (CGCP) in Aidarken settlement with capacities of the existing KMC's processing plant expanded from 0.1 million tonnes to 0.2 million tonnes during Phase I and to 0.7 million tonnes at a later stage. A CGCP with such capacity level will be able to service a number of neighbouring gold deposits. Furthermore, investments into development of non-metal ore deposits (mostly, construction materials) will make it possible to diversify the local mining sector.

During the conversion of the existing processing plant into the gold concentration plant and bringing its productive capacity from 100 to 200 thousand tonnes per year, its headcount will double to 160 people. The number of people employed in the gold concentration plant with an output of 500 thousand tonnes of ore per year will be 240 people. Thus, the total number of new jobs at the CGCP will be about 300-400 people. About 100 people will be necessary for transportation of the ore from the deposits to Aidarken settlement. In addition, part of the KMC's employees may be occupied at the neighbouring gold deposits in technical and mining jobs.

The ore processing project at the KMC's CGCP has a number of benefits compared to construction of a concentration plant and tailings pond at each deposit: a) lower level of capital expenditure, b) lower impact on the environment and mountain eco-systems and positive perception of the mining sector by the population, c) fewer permits, d) shorter time for project commencement, e) existing professional team of workers, operational infrastructure, production capacities together with industrial land available at KMC.

These advantages would be complemented by cost savings on surveying and prospecting for construction of several GCP, availability of a ready-for-use tailings pond and, most importantly, the possibility to commence the deposit development immediately, combining mining and deposit exploration simultaneously.

The existing processing plant at KMC has a design capacity of 200 thousand tonnes of ore per year. In fact, it has never processed more than half as much annually. The plant's equipment is outdated and needs to be modernised at an estimated cost of USD 2-3 million. In addition, a cyanidation and electrolysis line may be required to receive Dore bead.

The cluster GCP will be able to produce 6-7 tonnes of gold annually maximum and 300-400 permanent jobs will be created. `The construction cost of the new GCP will amount to USD 40-60 million.

The construction project of KMC's CGCP is considered to be realistic and potentially efficient, but requires organizational changes and agreements to involve the owners of rights to the gold deposits as well as government resolutions and approvals.

At present, the most likely ore source to KMC's GCP is the Altyn Dzhylga deposit. The reserves of this deposit were approved by the State Reserves Committee of the Kyrgyz Republic and now have the status of the mineable ones. In general, the deposit is ready for operation, but the local population has a negative attitude to the construction of a new tailings pond near the deposit. Surveying and prospecting operations are being carried out at the Aprelskoye deposit and the preparation of a report with reserve estimates is in progress. Geological exploration is currently under way at the Duva-Tash deposit. At the Chakush and Gavian deposits no substantial prospecting work has been carried out since the collapse of the Soviet Union and licenses have not been issued. The varying degrees of the deposit' development will determine the different time for starting operations and gradually increasing productivity. This will make it possible to prepare regulations for processing ores of varying mineral and chemical compositions, variable gold content and concentrations of harmful components (such as arsenic) for appropriate processing. Simultaneous mining of the nearby gold deposits and processing at the cluster GCP in Aidarken can provide 1,500-1,700 new jobs. In addition, indirect employment will add another 1,500 people. Thus, over 3,000 people will benefit from the gold extraction and processing project and non-metal mineral mining.

Following a comparative review of the two deposit development options (operation of individual GCPs and of KMC's cluster processing plant or KMC's GCP), preference should be given to ore processing at KMC both from the economic and environmental points of view. This option has a number of distinct advantages:

- In terms of all economic indicators (NPV, IRR, cash flow) ore processing in the Aidarken settlement, i.e. at KMC's GCP, is the more profitable.
- There is no need for construction of GCPs with tailings ponds and infrastructure facilities at each gold deposit. Thus, there is a decreased need for taking pasture and other land and the approval of tailings pond construction by local populations/authorities.
- The quantity of waste produced (processing tailings including cyano-containing ones) will decrease by 300,000 tonnes per year. KMC's cluster GCP will utilize the existing tailings pond after its upgrade. With that, the planned screening and enclosure of mercury-containing waste will make it possible to reduce the current levels of KMC's environmental impacts.
- Water consumption for ore processing will decrease compared to individual GCPs by almost 1 million cubic meters per year. This saving is significant given the water shortage in the densely populated and cross-border Sokh River basin. The introduction of recycled water will make it possible to reduce the use of clean water by 70% and exclude water discharges from the tailings.
- Centralized processing of ore at KMC will make it possible to cut total dust emissions into the atmosphere compared to ore processing at the sites. However, it will be necessary to use large dump trucks for transporting ore from the deposits to KMC, which is why total emissions from vehicle operation will grow.
- The overall impact on flora, fauna and mountain ecosystems in the area of deposit development will decline, and the negative effects on habitats, animal and bird migration will be minimal. Upon the exhaustion of the deposit reclamation will be required only for a limited area. In the case of individual processing and tailings at each deposit, large scale reclamation would be required.

Changing the production profile of the Khaidarkan Mercury Combine is unlikely to be possible using state financing, considering the current pressures on the national budget. Private investors could support the financial burden and risks, but that will require elaboration of all aspects of joint activity, because the mercury plant is state-owned. Apart from its commercial purpose the project to convert the mercury plant has an environmental objective - the reduction of mercury production and emissions in a socially responsible manner. Therefore, the participation of international donors and the provision of soft loans/grants are important. In particular, assistance is needed on organizational matters, the presentation of the case to investors, and support in technical design.

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