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MINISTRY OF MINING AND HEAVY INDUSTRY

METHODICAL RECOMMENDATION APPLIED FOR CLASSIFICATION OF MINERAL RESOURCES AND CERTAIN TYPE DEPOSITS' RESERVES OF MONGOLIA

(CHROMIUM)

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The METHODICAL RECOMMENDATION applied for classification of mineral resources and certain type deposits' reserves of Mongolia

CHROMIUM

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This recommendation is designed for employees of enterprises and organizations operating in the sector of subsoil use, regardless of their departmental affiliation (or subordination) and ownership.

The application of the "METHODICAL RECOMMENDATION" will useful to be provided geological information, the completeness and quality of which are sufficient to make decisions on further exploration or on the involvement of reserves of explored deposits in industrial development, as well as the design of new or reconstruction of existing enterprises for the extraction and processing of minerals.

Content

Preface

The recommendation was produced in accordance to a number of provisions of relevant law, decrees and regulations as follows: “Government policy on mineral resource”; “Mineral Law”-article 16; “Regulations on Mineral prospecting and exploration activities” approved by order #A/20, 2018 by the Mining & Heavy Industry Minister, as well as a provision approved by a Mining Minister order #203, on September 11th, 2015, which specifies that “The present recommendation for classification of mineral resources and deposit reserves can be applicable to a mineral resource in compliance with any recommendations for a certain type of mineral on the basis of its characteristics”. The methodical recommendation is geological resource, resource classification od the chroium deposit as well solid minerals resource.

The recommendations provide the practical assistance for entities who own exploration and mining licenses, geologists, prospectors, miners and ore mining organizations to compile a final report on reserve estimation, to have the estimated reserves registered to the state mineral resource register and update reserve data.

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One. Basic concepts

1.1. The chromium is a chemical element and pure chromium surfaces are silver and smoky blue colored and non-oxidizing at normal temperature; density of 7.19g/cm^3 /room temperature/, molten at 1890^{0}C and boiling point is 2327^{0}C and shinning and rare distribution.

Chromium is occurring 2 to 6 valences a chemical compound and 3 valency is resistant to corrosion, and 6 valency compounds having a strong oxidation property.

In 1797, the French chemist L. Vauquelin discovered chromium from a “Crocoite” mineral found in the Ural Mountains; and in 1854 R. Bunzen. mined a pure chromium.

Chromium is easily reacted with attenuated HCl & H_2SO_4 under normal temperature; and it is insoluble in HNO_3, H_3PO_4 & $HClO_4$ forming a protective film.

The chromium use from the early 19th century, such as extract paint, metallurgy; and later 20th century a wide use for industry to produce steel for oxidation and fire resistant.

A total of extracting chromium ore consumer is all industries; less than 50% to metallurgy, around 40% fire resistant materials and 10% the chemical industry.

Chromium is to clan group elements for forming alloys; ferrochrome, carbon & cobalt, nickel compounds stellite, chrome-nickel double alloy so called nichrome.

Ferrochrome is used in the metallurgy for making stainless (*Cr-18.0%, Ni-8.0%, C-0.1%*), fire resistant (*Cr-25.0-30.0%)* steel; and chrome & chrome magnesite uses to fire resistant factory; also uses of not melting at +2000^{0}C & no changes of volume at 1700^{0}C properties to make an amalgam; and manufacturing weaving mill and painting, tannery, extract oxide and salts. In addition, the chromium isotope a widely applying medical sector.

Nichrome (*Cr-15.0-20.0%)* is used widely to produce heating elements for electric stoves, ribbon, coil factory.

The chromium is also widely used in the vehicle industry as an important metal; 1.5% chromium is to make flexible, pill bearing steel and other all types of steel composition input with Mn, Ni, V.

1.2 Chromium (Cr) is a chemical element one of ferrous metal with the periodic table in group 6, atomic number 24, atomic weight 51.996. Naturally occurring chromium is four stable isotopes ^{52}Cr, ^{53}Cr and ^{54}Cr, with ^{52}Cr, the most abundant is ^{52}Cr (83.76%).

The chromium is lithophile element and its average value estimated by A.P.Vinogradov 0.0083%; estimated by F.Clark and G.Washington are 0.033% of the earth crust. The chromium content of ultramafic rock is approximately 0.20%; in mafic rock 0.02%, in felsic rock 0.001% and Cr_2O_3 value is 3.0-4.0% in magnesium rich olivine.

Chromium is a component of more than 30 minerals, the major chromium minerals of industrial importance are only the minerals of chromium-spinel group. But now only metallic-chromium and chromium are mined from them. A pure chromium is very rare and participating in the content of fuchsite, chromium-chlorite, chromium-vesuvian, rom-tourmaline chromium-garnet (uvarovite) in addition to chromium-spinel.

The chromium spinel group of minerals $(Mg.Fe)(Cr.Ai.Fe)_2O_4$ have originated at same geological circumstance and surface are very similar. Therefore, classifying minerals by their chemical composition similarity.

These includes: chromite $FeCr_2O_4$ (*meteorites and basic ore minerals*), magnochromite $(Mg,Fe)Cr_2O_4$, chrompicotite $(Mg,Fe)(Cr,Al)_2O_4$, aluminum chromite $(Mg,Fe)(Cr,Al)_2O_4$, subferrichromite (Mg,Fe) $(Cr,Al,Fe)_2O_4$, and less amount of subferrialuminochromite $(Mg,Fe)(Cr,Al,Fe)_2O_4$.

Among them Cr_2O_3 2–67 %, Al_2O_3 2–65 %, Fe_2O_3 0–41 %, FeO 10–30 %, MgO 1–20% minerals are varies widely.

Table 1: Major chromium minerals

Name of minerals	**Chemical formula**	**Chromium oxide/content, %**
Chromium-spinel	**$(Mg, Fe) (Cr, Al, Fe)_2O_4$**	**Cr_2O_3-18-62**
Stichtite	**$Mg_6Cr_2 [OH]_{16} [CO_3] 4H_2O$**	
Crocoite	**$PbCrO_4$**	**CrO_3-31.1**
Phenicochroite	**$Pb_3[CrO_4]_2O$**	
Vauquelinite (laxmanite)	**$Pb_2Cu[CrO_4]_3$**	
Uvarovite	**$Ca_3Cr_2[SiO_4]_3$**	**Cr_2O_3-30.6**
Kemmererite	**$(Mg, Fe)_5(Al, Cr) [AlSi_3O_{10}] [OH]_8$**	
Kochubeit	**Cr content clinochlore**	**Cr_2O_3-8.0 up to**
Volkonskoite	**$(Cr, Fe, Al)_4[Si_4O_{10}] [OH]_8 2H_2O$**	

1.3. The chromium industrial importance ore is usually massive, dense, porphyritic structure and containing high chromium oxide (32.0%<).

Depending on the composition of chromium-spinel which is contained in chromium ore is classifying, as massive (>90%), rich (70-90%), medium (50-70%), poor (30-50%) and fairly poor.

1.4. Chromium deposits are formed in early stage of marine; assembly of ultramafic rocks of the oceanic crust and correlation with ultramafic rocks of continental crust.

Rich chromium deposit formed due to separated and placed chromium enter to the host rock in late stage of ultramafic rock crystallization at deep circumstance.

Nest type of chromium deposit is formed in early stage of marine; and related to dunite-harzburgite massive. This type of deposit is known in Russian Ural, Balkan Peninsula, Turkey, Philippine island.

Larger chromium deposits are formed in hardburgite-orthopyroxenite massive, and its early stage of crystallization, which is associated with activation of tectonics and magmatism in the Precambrian.

Chromium mineralization is very rarely associated with a hydrothermal process but, chromium placers may form as a result of weathering of ultramafic rock.

1.5. The chromium is associated with platinum group of elements and it forming chromium industrial importance mineralization; it is not uncommon.

1.6. The chromium ore reserves are classified according to the 1986 Chinese 1986 classification. The ore reserve is 100 million tons or more than its large ore deposit; tens of tons is medium deposit; up to 1 million tons is a small deposit.

1.7. By 2012, the world's chromium identified ore reserves were 1.7 billon tons, from them more than 1.0 billion tons in South America; 550 million tons in Zimbabwe; 350 million tons in Kazakhstan; and 5.4 million tons ore mining per year.

Presently, South Africa, Kazakhstan, India and China are world's leading producers of ferrochrome.

In 2002-2008, China's ferrochrome production increased by 28.0% per year, and ore reserve were reached 1.5million tons. Major consumption countries are America, Western Europe; and 1 ton of 48% chromium oxide concentrate was 55$ in America; in Western Europe 60$, nevertheless by 2015 one kg of chromium price rich to 209$.

1.8 Mongolian chromium deposit and occurrences are associated Alpine-type hyperbasite rock as dunite (rich in magnesium) and harzburgite (rich in olivine).

By 2021, 24 zones of chromium-bearing hyperbasite have been identified on the Mongolian territory; and 19 of them are located in the Caledonian, and 5 of them in the Hercynian structure, respectively.

As of the end of 2017, about 50 occurrences and placer occurrences of chromium with a content of 20-55%, have been identified in Mongolia. In the explored Naran deposit, it was estimated that a total reserve of 733.19 t at Cr2O3-45.09% in 1462.9 t of chromium ore by industrial grade as well as 202.5 thousand t of resource in 410.4 thousand t ore in inferred category. Whereas, for the prospected Nogoon tolgoi deposit, the estimated reserve in indicated category reaches to 474.4 thousand t at Cr2O3-26.63% in 7.2 million t chromium ore, and 759.0 thousand t reserve at FeO-10.88%, as well as calculated resource totals at 211.7 thousand t at Cr2O3-15.3% in 39.2 million t ore and 4094.4 thousand t at FeO-10.82%. In addition, 530.3 t resource of chromium oxide in 1.63 million t ore was identified in the Jongiin gol occurrence.

Table 2: Mongolian chromium deposit and occurrences

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N	Occurrence name	Chemical formula	Content	Resource & reserve	Occurrence number	Area
1.	Group occurrence Naran	Cr_2O_3	41.88	Reserve 733.19, resource 202.2 thousand t	21	
2.	Occurrence of Nogoon tolgoi	Cr_2O_3 FeO	53,19	P3-15970	5	300 км^2
3.	Placer occurrence of Jongiin gol	хромит	40-800 мг/м^3	P3-6080+530		
4.	Group occurrence of Sulinkheer	Cr_2O_3	37-45		15+2	2.5-7 x 8-28 км
5.	Occurrence of Havtsal	Cr	0,24-31,5			50 x 1 м
6.	Occurrence of Dumberel uul	Cr_2O_3	44,4-48,7			
7.	Occurrence of Uul khiid	Cr_2O_3	29,25			

1.9 The chromium deposits difference is depending on the conditions in which they are formed, but their production value is determined mainly by the mineral composition of chromium ore. Chromium deposit not forming a large deposit of chrome-spinel type in the early stage of crystallization of ultramafic rocks.

It usually accumulates in the remnant of the magma melt in relation with differentiation of volatile components at the final stage of crystallization of ultramafic rocks. The rich content of magnesium in ultramafic rocks is making comfortable conditions for forming of the chromium ore. The chrome-spinel is stably remaining in the zone of hypergenesis and it is the genesis of chromium placer deposit.

The chromium industrial's importance deposits are the genetically classified to endogenic, exogenic and technogenic. Endogenic deposit is divided two sub-types as early magma and late magma. Including:

2.9.1. Endogenic deposits form genetically related to hyperbasite intrusive rocks which are subdivided into a. peridotite-pyroxenite-gabbronorite which is related to foliated magma; b. dunite-harzburgite which is related to Alpine-type of intrusion.

Early magmatic segregation deposits of chromium ores were formed at an early stage in the formation of ultra-basic intrusions of rocks and associated with differentiated (stratiform) layered arrays of the platform. Chromium ores are deposited in the lower horizons of the massifs, composed of dunites, peridotites, and pyroxenites.

Orebodies thickness is less stable and continued along the rockfall to tens of km, so even small thickness orebodies are having significant reserve. The ores are usually dense and have a dense mosaic texture. The less content of chromium or high content of iron type is available and belongs to a refractory material industry type and more high contents ore is used to metallurgy by general characteristics.

The main representatives of this ore are Bushveld in South Africa, Giant Del in Zimbabwe, Kemi in Finland, Stillwater in the America and India. An example Bushveld deposit is distributed along the 75000km^2 and located in foliated mafic and ultramafic rock of massive. In addition to chromium the massive contains mineralization of platinum, nickel, vanadium and magnetite. The following zones has formed in the massive: basic zone/lower zone (pyroxenite, harzburgite, norite); critical zone (norite, dunite, pyroxenite, chromium strata, anorthosite); main zone (gabbro, anorthosite, norite); upper zone (diorite, gabbro, anorthosite, magnetite strata).

1.5-2.0m of thick chromite layers are located surround to main massive along the general banding direction at basement portion of the critical zone.

The Bushveld igneous complex is classifying Lundeburg & Rustenburg ore zones and identified Cr_2O_3 -40,0-50,0%, FeO-23.7-25.8%, SiO_2-1,4-2,1% of ore content and reserve is 1 billion tons. In Mongolia, this type of deposit has been poorly investigated. Abundant concentration of ilmenite-titanomagnetite of lens and vein type has distrusted in early Paleozoic age of the Must-uul, Khojuuliin gol, Olon khudag massive. And the formation composited of Gabbro-anorthosite and observed small amount of chromium ore in Must-uul massive.

1.9.2. Late magmatic chromium deposits are formed in the late stage of segregation of massive dunite-harzburgite composition of ultramafic rocks of peripheral depressions. The orebodies are found as lens, column, and veins; greater ore body’s thickness is 250.0m; length 1550.0m. The deposit is including dozens of parallel packages bodies.

Chrome-spinel is containing chromium and aluminum replaced content belongs to the type of magnesium. This type of deposit is high chromium content ore is for metallurgy and high content of aluminum ore is for the refractory materials source.

The main representatives of this type of deposits are the South-Kimpersai group of deposits in Kazakhstan and the Guleman deposit in Turkey.

The Kimpersai group deposits consist of serpentinization ultramafic rock massive which is hanging blocks as lens and vein, along the stretched hundreds of meters long, 80m thickness bodies, same as South Ural.

Main ore minerals: chrome-spinel, olivine, serpentine; rarely magnochromite, aluminochromite, chrompicotite. Ore contents: Cr_2O_3 -50,0-60,0%, FeO-12,0-14,0%, SiO_2-4-10%, CaO-0.3%-д varies in respectively.

In Mongolia it is possible to determine this type of chromium deposits, associated to early Paleozoic dunite- wehrlite-clinopyroxent massive; and according to researchers (A.E.Izoh, G.V.Polyakov1990) they have established prospecting criteria that the Khan-Khukhii mountain range distinguished of Jargalant, Onts uul, Dariv massive contents of MgO-11.0-37.0%, Fe_2O_3-4-11.0 %

Table-3. Industrial type of endogenous deposit chromium ore

Industrial type	Ore formation	Ore type (composition)	Cr_2O_3 /%/ Content of ore	Ore type	Example deposits
Strata	Lenticuler-like bodies in basic-ultrabasite layer in foliated magma	Chromium (rich of Chrome)	23–24	Metallurgy	Sopcheozero
		Chromium (rich of Iron)	22–24	Industry of Chemical, refractory material	Aganozerskoye Big Vakara, Saranovsky
		Chromium (rich in iron & aluminum)	37	Industry of refractory material	Saranovsky
Alpine	Lens, vein of Ultramafic rocks	Chromium (rich of Chrome)	28–37	Metallurgy	Paradise-Iz (Central, Western, Southwestern)
		Chromium (Aluminum)	24–31	Industry of refractory material	Khoilins

1.9.3. Exogenous (placer) deposits (eluvial, deluvial, coastal-marine) arise as a result of destruction during weathering processes of endogenous chromite ore bodies and deposits. Their industrial value is limited. Examples are loose and powdered ores of the weathering crust of th Kempirsai deposits, deluvial placers and pebble ores of the Saranovskoye depoist8 the Great Dike8 marine placer of Japan, Yugoslavia.

These types of deposits do not have high chromium content. In Zimbabwe, the Cr_2O_3 -35.0% chromium content mine is upgraded to 53.0-55.0% by flotation. Estimated after identified of Jongiin Gol valley placer deposit of Mongolia. And these deposits can newly discovery in distributed zone of hyperbasite (chromium placer deposit in the Bayankhongor province of Cretaceous).

1.9.4.Technogenic deposits inclusde specia dumps of off-valance ores mined as a result of the development of chromium ore deposits, chromite-containing tailings formed in the course of ore dressing, in which the Cr_2O_3 content can reach 30% or more.There deposits require sepcific approaces to their study the and evaluation, the features of which are set out in the relevant regulatory and methodological documents and are not considered in these guidelines.

1.10. Chromium ore is genetically subdivided by 2 types, but other parts are presented as small amount (Table - 2). The industrial value of chromium ore is determined by the chemical composition of chrome spinel minerals, including toxic compounds CaO, S, P and $FeO+=FeO+0.9Fe2O3$ and SiO2-(8-10.0%), (Cr2O3: FeO+) < 2.5, Cr2O3> 32 determined by % content.

1.11. platinum group minerals are often found in chromium ore as by products, and sometimes occur industrial deposits. Ore-bearing peridotites, dunites and serpentenites can be used as refractory raw materials, while peridotites and anorthosites can be used as auxiliary minerals in the form of polishing stones.

Two. Grouping deposits by geological complexity for exploration purpose

Approved by order No.203 of September 11, 2015 of Minister of Mining of Mongolia Methodical Recommendation "Applied for classification of mineral resources and certain type deposits' reserves of Mongolia. The chromium deposit comprised of grouping by chrome-spinel group of minerals distribution, outer & inner structure, shape, size and thickness of ore bod as I, II, III and IV. 3.1.

2.1. **Group-II**. Simple and complex geological structure with ore bodies represented by large lenticular, vein-like and stratal deposits with a strike length or more than 300m, with a sustained thickness, divided by tectonic faults into separate blocks 50m or more in length (Miiionnoye, Almaz-Zhemchuzhina, XL years of the Kazakh SSR in Kazakhstan; Aganozerskoye in Russia). In the course of exploration, most of the reserves of group II deposits are assessed as measured (B)

2.2. **Group-III.** Very complex geological structure with ore bodies represented by medium and small lenticular and vein-like8 sometimes nests and pillar-shaped deposits ranging from tens of meters to 300b in length8 broken up by post-ore tectonics into small blocks The group includes Central deposit Rai-Iz massif, Polar Urals, Sopcheozerskoe; from Mongolia Naran, Nogoon Tolgoi deposit, Jongiin gol occurrenses. The reserves of the deposit are estimated according to the measured (B) and indicated (C) content.

2.3. **Group-IV.** Very complex geological structure of the deposit (section) is very complex, with significant changes in the mineral composition of the ore, intermittent nest-like formation, includes small veins, grids and horizontal bodies (mineralized sections) that are not of industrial importance on their own. At this time the research is very much of significant.

2.4. In some case deposits belong to the above groups changes of ore mineralization statistic changes.

2.5. Belonging of certain deposit (area) to a particular group is determined by the degree of complexity of the geological structure of the main ore bodies, in which the predominant part of the reserves of the field.

2.6. For determination of deposit into complexity of certain deposit group, the necessary quantitative assessments of some key parameters are recommended in following consideration:

Includes:

Mineralization coefficient (K_x) is for separation of the unit block of certain deposit reserve with the interrupted mineralization, and it is determined by the formula:

$$K_x = \frac{\sum l_i}{L};$$

Here: l_i – linear dimensions of ore intervals revealed by excavation and drill holes;

L – total linear dimensions of mineralized intervals revealed by excavation and drill holes;

Complexity coefficient (q) of the deposit is determined by the formula:

$$q = \frac{N_x}{N_x + N_{xг}}$$

Here: N_x – number of excavation and drill holes revealing mineralization;

$N_{xг}$ - number of excavation and drill holes revealing no mineralization;

Variability of thickness of ore bodies is determined by the following formula:

$$V_m = \frac{\sigma_m}{\overline{m}}$$

Here: V_m - variability coefficient of thickness of ore bodies;

σ_m - dispersion of thickness of ore bodies;

ḿ - average thickness of ore bodies.

d. Variability coefficient of useful component is determined by the formula:

$$V_a = \frac{\sigma_a}{\overline{a}}$$

Here: V_a - variability coefficient of useful component's content;

σ_a - dispersion of useful component of ore bodies;

ã - average thickness of ore bodies.

Statistic assessment and Complexity group for geological setting of deposit

Table-4.

Deposit group	Complexity indicators of geological setting of deposit			
	K_x	q	V_m	V_a
Group II	0,7–0,9	0,6–0,8	40–100	40–100
Group III	0,4–0,7	0,4–0,6	100–150	100–150
Group IV	< 0,4	< 0,4	> 150	> 150

Three. Geological setting of deposit and studies of ore mineral component

3.1. The of Geological prospecting of the chromium deposits is based on "Operational procedures for exploration, exploration and use of minerals" approved by order of No.A/20 on February 5th, 2018 by Minister of Mining and Heavy Industry, Mongolia; "Applied for classification of mineral resources and certain type deposit's reserves of Mongolia" approved by order of No. a/193 on October 3rd, 2019 by Minister of Mining and Heavy Industry, Mongolia; "Instructions for conducting and reporting electrical, magnetic, gravimetric and aerophysical cartographic work in Mongolia” approved by order of No.184 on July 20th, 2010 by Minister of Mineral Resources and energy of Mongolia prospectively.

Prospecting and geological mapping works on chromium ore shall be conducted in accordance to "Requirements and instruction for conduction of geological mapping and basic prospecting works at scale 1: 50000, within the territory of Mongolia" that approved by the order No.184 of the Minister of Mineral Resources and Energy issued on July 20th, 2017; and all types of geophysical surveys has to be completed in accordance to “Instruction for conduction of reporting procedures of electric, magnetic, gravimetric and air-borne geophysical surveys in the territory of Mongolia” that approved by the order No A/237 of Minister of Mining and Heavy Industry of Mongolia issued on December 12th, 2017.

3.2. For the explored deposit, it is necessary to have a topographic map, the scale of which would correspond to its size, the peculiarities of the geological setting and local landscape-geomorphological conditions; topographic maps and plans for chromium ore deposits are usually drawn up at a scale of 1:1000 to 1:10 000. To draw chromium deposit’s ore mineralization (clay, iron, silica) map using of aerial photography scale at 1:5000-1:10000

All exploration and operational workings’ excavations (trenches, dug holes, tunnels and underground mines), boreholes, profiles and stations of detailed geophysical observations, as well as natural outcrops of ore bodies and ore-zones should be instrumentally tied. Underground mine workings and boreholes are plotted to the plans according to the engineering survey (markscheider work).

Surveying plans of mining horizons are usually drawn at scale 1:200 to 1:500, but the combined plan map is drawn up at a scale not smaller than 1:1000-1:2000 due to the deposit’s size, geological setting and depend on geological mapping details.

For boreholes, the coordinates of the points of intersection of the roof and the bottom of the ore body should be calculated and their locations have to be plotted on plans and plane of sections.

3.3. The geological settings of the deposit should be studied in detail and plotted on the geological map at scale 1:1000 to 1:10 000 depending on the size and complexity of the deposit, and on geological sections at scale 1:500-1:1000, plans, projection planes, and, if necessary – on block diagrams and 3D models.

Outcrops and surface of ore bodies or mineralized zones are studied with traverses, geophysical and geochemical surveys, and excavation works and shallow boreholes, sampling procedures obtained from these surface works, which allow determining the condition of location, forms and size of ore-bodies, and structure, thickness and locating depth of oxidation zone, the degree of ore oxidation, detailed determination of mineral composition and technological properties of primary, mixed and oxidized ores; and reserve estimation of ores has to be completed separately for industrial (technological) types.

Geological and geophysical data on certain deposit should determine the size and shape of ore bodies, the conditions of their locations, the internal structure and continuity, the nature of the pinching out of ore bodies, the placement of different types of ores, features of changes in the host rocks and the relationship of ore bodies with host rocks, folded structures and tectonic faults, and their relationship to the host rocks, and sufficient to justify the calculation of reserves. Also, it is necessary to justify the geological boundaries of the deposit and the prospecting criteria that determine the location of prospective areas within assessed resources in P1-classification are estimated. A geological map and a map of mineral resources at scale of 1:25 000 to 1: 50 000 with corresponding sections are presented region of the deposit.

The specified materials should reflect the location of the ore-controlling structures and ore-hosting complexes of rocks, deposits and ore occurrences of the region, as well as sites on which the assessed resources of chromium ores are estimated. The results of geophysical surveys conducted in the region should be used in the preparation of geological maps and sections for them and reflect on the summary plans for the interpretation of geophysical anomalies on the scale of the maps presented.

3.4. Exploration methods for the deposit consists of drilling procedures, excavation works and geophysical studies, depending on condition of geological setting, and improving experiences of exploration and mining works are common to similar type of the current deposit.

Outcrops and surface of ore bodies or mineralized zones are studied with traverses, geophysical and geochemical surveys, and excavation works and shallow boreholes, sampling procedures obtained from these surface works, which allow determining the condition of location, forms and size of ore-bodies, and structure, thickness and locating depth of oxidation zone, the degree of ore oxidation, detailed determination of mineral composition and technological properties of primary, mixed and oxidized ores; and reserve estimation of ores has to be completed separately for industrial (technological) types.

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Exploration of chromium ore deposits to a depth is carried out mainly by boreholes with the maximum use of surface and downhole geophysical survey methods; and at a small depth of ore deposits – boreholes in combination with excavation works. In deposits of a very complex geological structure, which cannot be unambiguously interpreted according to drilling data, if necessary, it has to be conducted underground mining penetration to representative sites of ore bodies to determine the conditions of placement, internal structure, mineral composition and type ores, as well as to control the quality of previous drilling, geophysical works and sampling of pilot tests.

Methods of exploration – types and volumes of geophysical studies, their purpose and coordination with drilling procedures, the need for excavation, geometry and density of the exploration grid, sampling method and methodic have to correspond the deposit to the complexity group of geological structure, and they provide ability to reserve estimation in proper reserve classifications.

3.6. From core drill holes must be obtained the core in maximum recovery and complete volume and core is well preserved in length; the core can allow determination of placement, thickness and internal structure of ore bodies and host rocks, and alteration nature in vicinity of ore-body, and nature type of ores and their texture and structure well satisfying representativeness of samples. The accuracy of the determination of the linear core recovery shall be systematically monitored by weight or volumetric method.

From the practice of geological exploration works, the core recovery has to be not less than 90% for each run during the drilling. In case of core recovery decrease at interval of loose or crushed ores, the drilling slam (drill mud) has to be sampled together with the core samples, and the ore-interval shall be controlled and defined with geophysical downhole logging method.

The representativeness of the core that obtained to determine quality and thickness of ore-intervals must be confirmed by studies of the possibility of its selective abrasion. The representativeness of the core that obtained to determine quality and thickness of ore-intervals must be confirmed by studies of the possibility of its selective abrasion. The degree of selective abrasion is studied in relation to variegated core recovery and ore types. For this purpose, it is necessary to use data from the study of physical and mechanical properties of ores, data of samples obtained from excavation works and drill holes, down hole logging results, materials of exploiting exploration and mining operations, as well as the results of statistical processing of data on intervals with different core recoveries.

In the exploration of ore bodies composed of loose fractured ores, a special drilling technology shall be used to increase the recovery of the core (drilling without washing, shortened runs, the use of special drill muds, etc.). To increase the reliability and informativeness of drilling and quantitative assessment of reserves, it is necessary to use methods of geophysical studies in boreholes, the rational complex geophysical downhole surveys composing modern possibilities of downhole logging basis of the tasks convenient to certain geological and geophysical conditions of certain deposit. The downhole logging complex method, which is effective for determination of ore intervals and separation of their parameters, must be performed in all boreholes drilled at the site. For chromium ores it is necessary to carry out logging method of magnetic susceptibility, non-magnetic ores – nuclear geophysical methods, and weak magnetic – a complex of electromagnetic and nuclear geophysical downhole logging methods. In vertical boreholes with a depth of more than 200 m and in all inclined boreholes every 50 m, intervals have to be controlled measurements registering azimuthal and zenithal angles and determined the spatial position of the boreholes.

These measurements must be considered when constructing geological sections, horizontal plans of various levels, and calculating ore intervals. In the presence of intersections of boreholes by underground mine workings, the exact coordinates on the intersections have to be submitted by the data of underground survey tying. For boreholes, it is necessary to ensure that they cross the ore bodies at an angle of not less than 30°. For crossing steep or vertical ore bodies at large angle it is advisable to conduct inclined drilling procedures. To improve the efficiency of exploration, it shall be carried out drilling multi-hole boreholes, and in the presence of underground mining horizons – underground drill holes. Drilling in the ore, it is advisable to produce a single diameter.

3.7 The location of exploration workings and the distance between them should be determined for each structural and morphological type of ore bodies. And it has to be clarifying to use field and downhole geophysical survey methods for delineation of size, features of the geological structure and frame of ore-body distribution.

In the chromium ore deposit, it is advisable to use method of downhole magnetic survey; and in geological sections with a sufficiently clear differentiation by electrical properties, but with the ambiguity in results of borehole magnetic survey, in this case the most effective method is being downhole logging of electrical exploration.

In order to increase the efficiency of exploration by drilling, it is recommended to use multi-hole wells, and in the presence of mining workings, fans of underground wells. It is advisable to drill ore with one diameter.

Russia and Commonwealth of Independent States (CIS) is indicates the chromium exploration work is based on chromium mining experience, example of exploration net in classification (Methodological recommendations on the application of the classification of reserves of deposits and forecast resources of solid minerals Chrome ores Moscow 2007)

The summarized information on the density of exploration grid that used in the exploration of chromium ore deposits in the Commonwealth of Independent States (CIS) countries and Mongolia can be taken into account in the design of exploration.

The report including reserve estimation of mineral resources has to be completed in accordance to "Content of the Exploration Report Results of Mineral Resources and Its Requirements" that submitted by order No. 414 of Director of MRAM on September 9th, 2009 and "Procedures for conducting of the prospecting, exploration and mining works on mineral resources" that approved by order No. A/20 of Minister of Mining and Heavy Industry of 2018.

Generalized information about the density of the networks used in the exploration of chrome ore deposits can be used in the design of geological exploration, but they cannot be considered mandatory.

Chromium ore deposit density of networks woring used in rrequirements of the Instruction "Classification and guide of Mineral Reserves Mineral Resources of Deposits" of the Minister of Mining of Mongolia in 2015, and recommend below density of networks of exploration working used in exploration chromium ore deposit (table 5)

Information on the density of networks of exploration working used in exploration chromium ore deposit

Table 5.

Deposit group	Structural - Morphological type of ore bodies	Work type	Distance between exploration workings corresponding to reserve classification, m			
			B		C_1	
			along with dipping direction	along with strike	along with dipping direction	along with strike
1	2	3	4	5	6	7
Before 1996, Russia						
II	**Large reservoir- and lens-shaped deposits with sustained power:**					
	length >1000 m	**Drill hole**	**60**	**80**	**60-80**	**80-120**

	length >300 m	**Drill hole**	**20-30**	**40-60**	**40-60**	**80-120**
III	**Vein- and lens-shaped, sometimes nesting and columnar bodies of small size, ranging from n * 10 to 300 m, broken up by post-ore tectonics into small blocks**				**20-30**	**40-60**
Recommened in Russia /in present/						
1	**2**	**3**	**4**	**5**	**6**	**7**
II	**Aganozerske – Large (Main) chromite horizon, strata, gentle fall**	**Drill hole**	**20-60**	**100-200**	**20-60**	**400**
II-III	**Sopcheozerskoye - shallow ore bodies and deposits**	**Drill hole**	**12**	**25**	**25-50**	**50**
III	**Vertical dip stripes and meshy-like objects up to 10-500 m long /Tsentralnoye deposit /**	**Drill hole**			**20-25**	**20-50**
		Tunnels				**10-20**

Summarized information on the density of exploration grid at exploration on chromium ore used in Mongolia

Table 6.

Deposit group	Structural - Morphological type of ore bodies	**Work type**	Distance between exploration workings corresponding to reserve classification, m			
			Measured (B)		Indicated (C)	
			along with dipping direction	along with strike	along with dipping direction	along with strike
II	Aganozerske – Large (Main) chromite horizon, strata, gentle fall	Drill	20-60	100-200	20-60	200
III	Sopcheozerskoye - shallow ore bodies and deposits	Drill			20-25	50-100
IV	Central – steeply falling veins and lenticular bodies with a length of 10-500 m	Drill			20-25	20-50
Note: In the estimated fields, the exploration network for category C_2 is 2-4 times thinner than the network for category C_1, depending on the complexity of the geological structure of the field.						

For certain deposit, the most rational geometry and exploration grid density are justified on the basis of studying data of the deposit or available geological and geophysical data or results of detailed and careful analysis of all and operational materials of similar deposits.

Applying several methods to use in addition to comparation method in exploration grid density optimization. Such as experimental methodological research methods, thinning method, mathematical-statistical methods, geostatistics etc. In international exploration practice, statistical or geostatistical methods are widely used to maintain a consistent relationship between data.

In Mongolia the chromium deposit is belong below Group-II of deposits depend on the geological complexity setting. Therefore, might be no more than 80% is indicated (C), no more than 40-50% is measured (B) version and to ensure exploration grid density optimization to apply of ore body estimation and related parameters.

3.8. To prove confidence of deposit specifies part which is estimated by exploration work (especially leading mining part) to make an detailed exploration work, the reserve has been calculated as the highest grade corresponding to the composite group of geological formations of the deposit.

The part to be studied in detail is a part that included within the reserve contour, it should be capable to represent the general pattern of the deposit by its geological characteristics, and is possible of initiating future mining. Chroiumum deposit's detialed study part is among the geological characterization, general representative capacity, potential exploration/mining, deposit resource.

These parts should be studied and sampled by denser exploration grid comparing with other parts of the deposit.

The location and size of this detailed study area will be determined by the explorer based on the characteristics of the geological settings of the deposit and the conditional parameters selected by the feasibility study to mine the deposit.

When using the geo-statistic method for the reserve estimation of the detailed study parts, the density of exploration grid should be sufficient to justify the optimal interpolation formulas by inverse distance, kriging and other methods.

If the areas to be mined in the first priority do not represent the deposit as a whole in terms of feature of geological settings, ore quality and mining-geological conditions, other areas that can meet this requirement should be studied in detail.

In addition, the size optimization of non-conditional (sub-standard) ore and barren rock areas should be taken into account the minimum size of areas for selective mining that can be mined for future.

For the area of the deposit's all data that subjected to opitmal research of other part of deposit.

For group-II explored deposit mineral reserves are estimated in measured (B) and group-III-IV is in indicated (C). For group-IV mineral reserves are estimated in indicated (C) and identifcal resource (P_1).

3.9 All exploration workings, boreholes and outcrops of ore bodies must be documented. The sample results have to be written to the primary documentation and checked correlatively with the geological description.

Specially appointed commission has to monitor completeness and quality of primary geological documentation, which meets compliance with deposit's geological features, correctness of determination of the spatial position of the structural elements, the preparation of sketches and their descriptions in the prescribed manner. Furthermore, it should be controlled and assessed quality of geological and geophysical sampling (consistency of cross-section and weight of samples, their position corresponding to the peculiarities of the geological structure of the deposit, the completeness and continuity of sampling, the presence and results of control testing), the representativeness of mineralogical and engineering-hydrogeological studies, the determination of volume weight, sample processing and quality of analytical work.

3.10. To study the quality of the mineral, delineate the ore bodies and the estimate the reserves, all ore intervals revealed by exploration workings and determined interval in natural outcrops must be sampled.

At evaluation stage or early stage of exploration works, the choice of sampling methods (geological and geophysical) and methodic is based on data related to geological setting's features of the deposit, as well as the applied technical characteristics of that time.

The reliable data obtained by geophysical methods (magnetic and nuclear-geophysical) can be used instead of routine sampling procedures. However, the possibility of geophysical data to substitute the rock samples, it has to be checked and submitted.

3.11. Sampling of exploration sections shall meet the following conditions:

- the sampling grid must be consistent; its density is determined by the geological setting's features of the studied areas of the deposit;
- samples must be taken in the direction of maximum variability in mineralization. If the ore bodies are crossed by boreholes at an sharp angle to the direction of maximum variability (in this case, it will be appear some doubts about the representativeness of sampling), the sample results have to be controlled by comparison way and signed the possibility of using these sections in the reserve estimation;
- sampling procedures should be carried out continuously, at full thickness of the ore body and in as possible as equal intervals with an output in the host rocks by an amount exceeding the thickness of the ore body and entering into layers of gangue rock or substandard contents of ore; in the exploration workings, it shall be sampled ore body outcrops and their weathered parts, too;
- natural varieties of ores and mineralized rocks should be tested separately – sections; the length of each section (ordinary sample) is determined by the internal structure of the ore body, the variability of the mineral composition, textural and structural features, and other properties of ores, as well as the length of the run. And intervals with sharply different core recovery are sampled separately.

3.12. The quality sampling for each accepted method and for the main types of ores should be systematically monitored, assessing the accuracy and reliability of the sampling results. The position of the samples relative to the geological structure elements and the reliability of delineation of ore bodies' thickness should be checked in periodic manner, and the actual sample weight should be calculated based on the actual diameter and core recovery (deviations should not exceed ± 10–20% taking into account the variability of ore density). Accuracy of core sampling should be controlled by sampling from the second halves (duplicates) of the core.

3.13. Reliability of content determination with downhole logging shall be confirmed by comparison of its data on the main types of ores with sampling results taken from marked (referenced) boreholes with a high core recovery (above 90 %). The reliability of core sampling from ordinary boreholes should be confirmed by geophysical sampling data separately for different classes of core recovery. In presence of selective abrasion, significantly distorting the sample results, the reliability of core sampling, if possible, is confirmed by sampling the neighbor (or closest) mine workings.

For existing mine enterprises, the reliability of the adopted methods of sampling is certified by comparing data within the same horizons, blocks and parts of the deposit data obtained separately from mining operation and core drilling procedures. The amount of control samples should be sufficient for statistical processing of sample results. and reasonable in case of presence of systematic errors, and, if necessary, for the introduction of correction factors.

3.14. Sample processing is performed according to the deposit feature or adopted schemes by analogy with similar deposits. The main and control samples are processed according to the same scheme. The sample processing quality must be systematically monitored for all operations including ore-crushing, mixing, sieving and sample reducing. Control processing of large-volume samples is made according to specially designed programs.

3.15. The chemical composition of ores should be studied with completeness, providing a reliable assessment of their quality, the identification of harmful impurities and useful associated components. The analysis for determining the chemical composition of the ore shall be carried out by chemical, atomic absorption spectrometry (AAS-10 and AAS-fire assay), ICP other methods, depending on the chemical properties of the element to be determined, in accordance with analytical methods, instructions and standards.

If no instruction has developed for study of ore associated contain, could use to equivalent of the Russian “METHODOLOGICAL RECOMMENDATIONS” on the application of the Classification of reserves of deposits and forecast resources of solid minerals.,2007

3.16. The quality of the sample analyzes should be systematically checked, and the results of the monitoring should be processed in a timely manner. Geological monitoring of sample analyzes should be carried out independently of laboratory internal monitoring throughout the entire exploration period on the deposit. The results of tests for all major, accompanying and slag-forming components and harmful impurities are subject to control.

3.17. To determine the values of random errors it is necessary to carry out internal control by analyzing encrypted control samples taken from duplicates of analytical samples in the same laboratory that performs basic analyses.

To identify and assess possible systematic errors, external control should be carried out to a laboratory, which has the mandatory of control. For the external controlling analyses, it has to be selected duplicates of analytical samples stored in the main laboratory and passed internal control. In the presence of standard samples of composition (SSC) similar to the samples under study, external control should be carried out, including them in encrypted form in a batch of samples that are submitted for analysis to the main laboratory.

In modern time, common uses to determine sample testing quality by analyzing of standard samples, duplicate samples, empty or unfilled samples, reference samples including of 20-25 pieces of group samples in the main laboratory.

For prepare empty or unfilled samples, to collect not mineralization sample from the surface which is located by ore mineralization or nearby ore deposit. And the collected sample must analyses by minimum two laboratories and not contained of chromium.

The etalon samples should be prepared from bulk samples with a weight of not lesser than 20 kg collected from the main types of ore of the deposit, equivalent to 3 levels of grade: cut grade, average grade of the deposit and high grade. The content of the etalon samples should be tested and confirmed in at least 3 independent laboratories. All types of control samples to be tested in conjunction with the main sample shall be included in the main sample and assigned a serial number and sent for analysis.

3.18. The amount of internal and external control should ensure the representativeness of the selected samples for each content class and exploration period (quarter, half-year, year).

Samples sent for internal and external control should characterize all varieties of ores of the deposit and grades.

In order to determine the content group, it should be considered the cut-off grade and minimum industrial grade and the requirements can be followed such as internal control should cover 5-8% of the total samples, external control in 5%, and 5% in the case of more than 1000 samples per year.

20-30 samples are subject to control for each class of contents for which systematic discrepancies have been identified at internal and external control.

Processing of internal and external control data for each content class is carried out by periods (quarter, half-year, year) separately for each method of analysis and laboratory performing basic analyses. Evaluation of regular error evaluations as a result of the analysis of standard composition samples is carried out in accordance with the statistical methodology. Acceptable maximum margin of error (Standard Deviation) identified as a result of internal control should not exceed the limit values shown in Table 77. Alternatively, the laboratory's current work results will be reversed and the samples will be re-analyzed with internal geology control. At the same time, the testing laboratories should identify the causes of their work and eliminate mitigation measures.

The relative standard error determined by the results of internal control should not exceed the values indicated in table 7.

Value of random error (%), is determined by the formula:

$$m_y = \sqrt{\frac{\sum (C_y - C_x)^2}{n}} \quad ; \quad m_x = \frac{2 \cdot m_y}{\bar{C}_y + \bar{C}_x} \cdot 100\%$$

m_y −absolute error,

m_x – relative error.

$\overline{C}_y, \overline{C}_x$ – average value of basic and control analysis, and it determine by the formula:

$$\overline{C}_y = \frac{\sum C_{yi}}{n}; \qquad \overline{C}_x = \frac{\sum C_{xi}}{n};$$

Maximum permissible relative standard errors of analyses

by content classes

Table 7.

Compo nent	Grade classification, %	Acceptable maximum margin of error, %	Compo nent	Grade classification, %	Acceptable maximum margin of error, %
Cr_2O_3	40-60	1.2	MgO	20-40	3
	20-40	1.8		10-20	4.5
	10-20	2.5		1-10	9
	5-10	3.0		0.5-1	16
FeO	12-17	4.0	TiO_2	0.1-0.2	20
	5-12	5.5		0.02-0.1	28
	3.5-5	10		0.01-0.02	35
CaO	1-7	11	Mn	0.2-0.5	10
	0.5-1.0	15		0.1-0.2	13
	0.2-0.5	20		0.05-0.1	20
P_2O_5	0.05-0.1	15	S	0.05-0.1	20
	0.01-0.05	25		0.01-0.05	30
	0.001-0.01	30		0.001-0.01	30
SiO_2	5-20	5.5			
	1.5-5	11			

Note: If the content classes allocated at the deposit differ from those indicated, then the maximum permissible relative standard errors are determined by interpolation.

3.19. In case of detection of systematic differences between the results of the analysis of the main and the controlling laboratories according to the external control, arbitration control is carried out a laboratory that accredited in International level and certified to such kind of activities. The analytical duplicates of ordinary samples stored in the laboratory (in exceptional cases, the remains of analytical samples), for which there are the results of ordinary and external control analyses, are sent to arbitration control. 30-40 samples for each class of contents for which systematic discrepancies are revealed are subject to control. If there are SSC similar to the samples under study, they should also be included in the encrypted form in the batch of samples submitted for arbitration. For each SSC, 10-15 control tests should be obtained.

When the arbitration analysis confirms the systematic differences, it is necessary to find out their causes and develop measures to eliminate them, as well as to decide whether it is necessary to re-analyze all samples of this class and the period of operation of the main laboratory or to introduce an appropriate correction factor into the results of the main analyses.

Without arbitration analysis taken by Laboratory with International Accreditation, the introduction of correction factors is not allowed.

3.20. The mineral composition of ores, their textural and structural features and physical properties should be studied using mineralogical, petrographic, physical, chemical and other types of analysis according to the methods approved by relevant scientific research organization on mineralogical and analytical research methods.

In addition, for ores that need to be enriched, grain sizes and the ratio of differently sized classes and silicate minerals related to chromium must be determined.

Mineralogical studies, the distribution of chromium and accompanying components and harmful impurities should be studied and a balance or ratio of their distribution in the forms of mineral compounds should be made.

3.21. The definition of volume weight and moisture of the ore is necessary to be determined for each natural type and gangue or low graded substandard interlayers of rocks. The volumetric weight of the ore can be determined in the laboratory condition with representative samples, in the case of porous and fractured ores it can be defined in the field by penetrating into the rock mass using an excavation (eg.1m^3) and comparing the weight of the ore from the excavation to the well-defined volume of the excavation.

Also, determination of the volume weight can be made by method of absorption of scattered gamma radiation at presence of the required amount of verification work. The samples and specimens for determination of volume weight and moisture content should be subjected to mineralogical studies and analyzed for major components.

3.22. As a result of the study of chemical, mineral composition, texture and structural features and physical properties of ores, their natural types are determined and industrial (technological) types requiring selective extraction and separate processing are planned on preliminary basis.

The final determination of industrial (technological) types and ore grades are made on the basis of the results of technological study of the natural varieties identified at the Deposit.

Four. Study on technological property of ore processing

4.1. Sampling for technological research at different stages of geological exploration should be carried out in accordance with SRT RosGeo 09-001-98 "Solid minerals and rocks. Technological testing in the process of geological exploration".

The pilot tests of ores, as a rule, are studied including all kinds of tests and laboratory analyses on natural (mineralogical) and technological types of ores.

4.2. For the rational use of the reserves of the deposit and the creation of an effective technology for the enrichment of ordinary and poor ores, it is advisable to use a quality management system of extracted raw materials, the main element of which is large-batch radiometric sorting in transport containers.

Analysis of its capabilities in chrome ores – removal of dump rock (external and internal dilution), allocation of rich commercial products and ore for enrichment - is carried out in accordance with the relevant regulatory and methodological documents. As a result of the research, the contrast of ores in terms of Cr_2O_3 content in the natural occurrence for portions of different volumes should be evaluated based on sampling data (geological and logging) and the expected separation indicators calculated.

Determination of technological indicators and evaluation of the effectiveness of the sorting tasks to be solved, establishment of a physical separation method (neutron activation or X-ray radiometric), determination of the material composition of the sorting products sent for enrichment, clarification of the optimal volume of the sorted portion and analysis of the effect of ore mixing during mining are carried out on large semi-industrial samples or during experimental development of sites, based on the planned mining technology.

With positive results of the application of radiometric sorting technology, it is necessary to clarify the industrial (technological) types of ores that require selective extraction, or to confirm the possibility of gross ore extraction.The analysis of chromium ore technology and all enrichment activities in accordance with applicable procedures in Mongolia comply with the recommendations that are expected to be developed and implemented. Alternatively, the same type can be used for approved recommendations.

4.3. In the process of technological research, it is advisable to study the possibility of pre-enrichment and (or) separation into grades of mined ore in heavy suspensions, using large-portion sorting of the ore mass in transport tanks, and for ores with a high yield of lump fraction the possibility of their radiometric separation.

In case of positive results from the use of pre-enrichment technology, the types of ore extraction (technological) that need to be classified should be detailed, or the possibility of bulk ore extraction should be confirmed.

Further tests of ore processing methods by traditional methods of deep enrichment (gravity, magnetic separation, flotation) are carried out taking into account the technological capabilities and economic efficiency of inclusion in the general technological scheme of radiometric separation or enrichment in heavy suspensions in accordance with the "Solid non-combustible minerals.

4.4. The technological properties of ores requiring enrichment are usually studied in laboratory and semi-industrial conditions using mineralogical, low-tech, laboratory, laboratory enhanced and semi-industrial technological analyses.

If there is experience in processing with similar characteristics, similar results can be used, which are confirmed by the results of laboratory studies. For hard-enrichable or new types of ores, for which there is no processing experience, technological studies of ores and, if necessary, their enrichment products should be carried out according to special programs agreed with the customer and the regional subsoil fund management body.

4.5. All natural (mineral) ore varieties identified at the deposit should be characterized by mineralogical and small technological samples. According to the results of their tests, geological and technological typing of the ores of the deposit is carried out with the final isolation of industrial (technological) types and grades of ores, the spatial variability of the material composition, physico-mechanical and technological properties of ores within the selected industrial (technological) types is studied, and geological and technological maps, plans and sections are compiled.

The technological properties of all selected industrial (technological) types of ores requiring enrichment are studied on laboratory and enlarged laboratory samples to the extent necessary to select the optimal technological scheme for their processing and determine the main technological indicators of enrichment.

4.6. Semi-industrial technological samples are used to check technological schemes and refine the indicators of ore enrichment obtained from laboratory samples.

4.7. Enlarged laboratory and semi-industrial technological samples should be representative, i.e. meet the chemical and mineral composition, structural and textural features, contrast in the content of a valuable component, types in the density of chromium spinelide, physical and other properties of the average composition of ores of this industrial (technological) type, taking into account possible dilution.

In all the stages of geological exploration work, the pilot tests revealing technological properties of ore are also carried out at different levels and the bulk samples for the pilot tests are taken according to the established "Technical recommendations on ore technology analysis and Technical recommendations on magnetic, Gravity and filtration tests in ore".

4.8 Technological parameters of commodity ores that do not need to be enriched, which are obtained directly during mining or after large-batch radiometric sorting, and their compliance with consumer requirements are determined based on the study of their complete chemical, mineral and granulometric composition and analysis of Cr2O3, FeO, Fe2O3, SiO2, CaO, phosphorus, sulfur, impurities (clay, waste rock, chips), calcination losses for each class of fineness.

4.9. The basic scheme for studying the enrichment of medium and poor-quality ores (20-40% Cr2O3) is a technological scheme for multistage extraction of a valuable component as it is disclosed, which is based on gravitational processes. At the first stage, after large crushing of raw materials, a lump concentrate of solid and densely interspersed ores is extracted from different classes and dump tails are removed. The size limits of the material are determined by the enrichment processes used in heavy suspensions (-100+10 mm) or radiometric separation (-200+15 mm). The second technological operation is jigging with a material size of -15(10) +1(0.5) mm. It is designed to extract ore differences rich in density of inclusions from the screening, which was not enriched at the first stage, and to recover similar components of raw materials from the crushed industrial product of lump separation. The final stage of processing of raw materials is carried out on the industrial product of the previous stage, crushed to the optimal size of the chrome spinel disclosure, to obtain the richest concentrate. At this stage, it is advisable to use the concentration of the material on tables or in combination with screw separators. This technological scheme, depending on the complex of natural properties of the feedstock, is modified only according to the composition of the stages of enrichment processing.

4.10. The final stage of processing of raw materials is carried out on the industrial product of the previous stage, crushed to the optimal size of the chrome spinel disclosure, to obtain the richest concentrate. At this stage, it is advisable to use the concentration of the material on tables or in combination with screw separators. This technological scheme, depending on the complex of natural properties of the feedstock, is modified only according to the composition of the stages of enrichment processing.

Magnetic separation in strong fields (up to 800 kA/m) is an effective method of enrichment of fine–grained ore classes and refinement of industrial product concentration on tables, and for thin classes - high-gradient magnetic separation.

For the enrichment of chromium ores, it is possible to use flotation technology, the use of which is most appropriate only when extracting chromium spinelide from thin classes where gravity processes are not efficient enough, i.e. from industrial products and tailings. Depending on the basis of the rock complex (olivine or serpentine), various flotation schemes are implemented: fatty acid collectors, cationic flotation, etc.

4.11. Promising areas of improvement of ore dressing technology are:

-radiometric separation, and for some types of ores – large-lump jigging;

-magnetic separation with a high-intensity magnetic field of small-lump material (-10 mm) on electromagnetic rotary separators;

-preparation of ore in the grinding cycle (for example, selective dispersion) to reduce the sludge formation of chrome spinelide.

4.12. As a result of the studies carried out, the feasibility of using the process of large-portion radiometric sorting should be established, the mineral and chemical composition of the initial ore and all final products of each stage of enrichment should be determined, information on the crushability and grinding of ores, information on the density, bulk weight and moisture content of the initial ore and enrichment products, data on the granulometric composition of the ore after coarse and fine crushing, fine grinding, on the size of commercial and waste products, a technological scheme of the entire enrichment cycle, parameters of enrichment processes (including the reagent mode of flotation), a circuit diagram of apparatuses and a qualitative-quantitative scheme of processing with operational indicators, end-to-end technological indicators of enrichment are given - the yield of products, the content and extraction of Cr_2O_3 and associated components in them, the enrichment factor. The quality of the enrichment products must meet the requirements of the customer or existing standards and specifications.

4.13. Differentiated requirements are imposed on commercial chrome ores and their enrichment products in various industries, both in terms of chemical composition, the amount of foreign impurities, and the size of the material.

In metallurgy, the production of ferroalloys requires ores in large-lump form of the highest quality with a Cr_2O_3 content of more than 45% with a ratio of Cr_2O_3 to FeO+ of at least 2.5 and a limited amount of SiO_2, phosphorus and sulfur.

Currently, there is no chromium mining in Mongolia, and there are no relevant technological studies, ore quality requirements or examples of ore grades used.

For the same reason, the brand and quality indicators currently used in Russia are given as examples.

TU 14-9-102–76. Chrome ore of the Don GOK (for the production of refractory products)

Table 8.

Quality indicators	Norm (in %) for ore grades		
	DX-2-0	DX-2-1	DX-2-2
Cr_2O_3, not less	52.0	50.0	45.0
SiO_2, not less	6.5	8.0	8.0
FeO, not less	14.0	14.0	14.0
CaO, not less	1.0	1.0	1.3

Note:

According to the granulometric composition of chrome ores should be supplied: 1st class (fine) 0-10 mm, 2nd class (large) 10-300 mm, 3rd class (ordinary) 0-300 mm. The content of small change (0-10 mm) in lump ore of the 2nd class (10-300 mm) is allowed no more than 30%.

TU 14-9-220–81. Chrome ore of the Don GOK (for the production of ferroalloys)

Table 9.

Quality indicators	Norm for ore grades	
	DX-1-1	DX-1-2
Cr_2O_3 content, not less, %	50.0	47.0
SiO_2 content, no more, %	7.0	9.0
Ration Cr_2O_3 contents to FeO, not less	3.5	3.0
P content, no more %	0.005	0.005
S content, no more, % (for size classes 2–6mm)	0.05	0.05

Granulometric composition of ores
(for ferrochrome production)

Table 10.

Size class	Size of the pieces, mm	Content of the class in the batch, no more, %	
		Above the grid	Into the grid
1	0-10	10	–
2	10-80	15	30
3	80-300	10	30
4	0-300	10	–
5	10-20	10	20
6	20-80	10	30

TU 14-9-219–81. Chrome ore of Donskoy GOK
(for the production of chrome compounds)

Table 11.

Quality indicators	Norm (in %) for ore grades
	DX-3
Content of Cr_2O_3, average	49.0
Content SiO_2, average	8.0
Content FeO, not less	14.5
Moisture, no more	5.0

Note: According to the granulometric composition, chrome ores should be supplied with a size of 0-10 mm. In agreement with the consumer, the supply of ordinary ore with a size of 0-300 mm is allowed.

TU 14-9-149–78. Chromium boulder ore of the Saranovskoye Deposit (for foundry production)

Table 12.

Quality indicators	Norm
Cr_2O_3 content not less, %	36.0
CaO, content no more %	0.4
Impurities (clay, rock, wood chips, etc.), no more, %	5.0
Losses during calcination, no more, %	2.0
Ore size, mm	40-350

TU 14-9-148–78. Chromium ore of the Saranovskoye deposit (for the production of chrommagnesite products

Table 13.

Quality indicators	Norm
Content of Cr_2O_3, % (permissible deviation in the content of chromium oxide ±2 %)	36.0
SiO_2, not less %	8.5
CaO, not less, %	2.0
Class 10-350 mm, not less, %	90.0
class 0-10 mm, no more, %	10.0
Note: *1. The upper limit on the content of chromium oxide is not limited.* *2. The ore must not contain foreign impurities of clay, calcite pieces larger than 15 mm, wood chips and other wood inclusions.*	

TU 14-9-250–83. Composition of chromite concentrates

(for the production of ferroalloys and refractory products)

Table 14.

Quality indicators	Norm for ore grades (%)		
	KXD-1	KXD-2	KXD-3
Cr_2O_3 not less, %	48.0	50.0	50.0
SiO_2 no more %	8.0	7.0	7.0
Ratio of Cr_2O_3 & FeO no less	0.8	0.8	0.8
P content, no more, %	0.05	0.08	0.08
S content, no more, % (for size classes 2-6mm)	0.005	0.005	0.005
Ratio Cr_2O_3 & FeO no less	3.5	3.5	3.6
Size, mm	100-10	10-3	3-0
The content of classes, no more %:			
–0,5 mm	–	–	70
–3 mm	–	15	–
–10 мм	15	–	–

Chromite concentrate for high-refractory products

Table 15.

Quality indicators	Norm
Cr_2O_3, not less,%	57,0
SiO_2, not less, %	3,0
CaO, not less, %	1,0
Size, мм	0,5–0

In other countries, the general requirements for chrome ores and concentrates are as follows. These include:

Metallurgical varieties – More than 48% of the content of the Cr_2O_3; SiO_2 and 3% no more, and $MgO+Al_2O_3$ from 25% less than; the ratio of chromium and iron is more than 2.8; preferably solid and versatile ores;

Refractory varieties – About 31% of the content of the Cr_2O_3, SiO_2 no more than 6%, iron not more than 12% and Al_2O_3 not more than 25%; preferably solid and versatile ores;

Chemical varieties - About 45% of the content of the Cr_2O_3, SiO_2 no more than 5%, Al_2O_3 no more than 25%, ratio of chromium and iron 1.6; powdered ore preferably.

Five. Studies on hydrogeological, engineering geological (geo-technical), geo-ecological and other natural conditions of deposit

5.1. The Studies of hydrogeological condition of the deposit is based on "Instruction for conducting Hydrogeological Surveys During Thematic, Medium and Large-scale Hydrogeological Mapping and Mineral Resource Exploration Works, and Requirements to the Exploration Activities" approved by order of No. A/237 on December 12th, 2017 by Minister of Mining and Heavy Industry, Mongolia.

5.1.1. Hydrogeological studies that will be carried out during the exploration will be conducted to study the hydrogeological conditions of the deposit, determine ways to prevent flooding of the mine and solve problems with the water supply of the concentrating plant and the concentrating plant and for household needs.

5.1.2. The hydrogeological conditions of the deposit will determine the lithological composition of each aquifer, the distribution location, thickness, reservoir type, recharge conditions, the relationship between aquifers and surface waters, the groundwater level in wells and mine workings, the volume of water entering the mine, and other parameters.

The chemical composition and bacteriological conditions of the water entering the mine, the impact on the concrete, metal and polymer structures of the mine, as well as the concentration of useful and harmful impurities and compounds in the mine water will be determined.

The chemical composition of groundwater, the composition of groundwater, changes and environmental impacts were determined.

If the deposit is contained in permafrost zone, it has to be conducting geo-cryology surveys to the deposit

5.1.3. It has to be determined condition of drainage water disposal, the impact of mine water discharge and water reservoirs on the hydrogeological condition of the deposit area, possible changes in the condition. Also, it has to be assessed the possibility to use the drainage water into industrial water supply of the future mine enterprises and to extract and process useful components from mine water.

The hydrogeology study of the mine (pit) is going to determine impacts of water inflow from underground water, surface water and atmospheric precipitation and flooding.

5.1.4. The study of hydrogeological conditions of the mines are different depending on complexity of the deposits' hydrogeological conditions.

Deposits of simple hydrogeological conditions are characterized by aquifer that is located in well cemented, stable rocks, and water inflows into the mine does not exceed 1,000 m^3/h; deposits of medium level of hydrogeological conditions are characterized by underground water is contained within tectonic faults and fractured zones, which may cause flood the mine site, and water inflows can take maximum 1500 m^3/h; deposits of complicated hydrogeological conditions are characterized by aquifers that suffered intensive faults and fractures zones, saturated with underground water and water inflows into mine taking greater than 10000 m^3/h.

On deposits of simple hydrogeological conditions: the hydrogeological studies include measuring underground water level measurement in excavation works and boreholes, assessment of water debt rates, survey on fractures of aquifer rocks, wall stability of borehole, study of drill mud loss, and water level increase, if borehole penetrated (artesian) aquifer under pressure; and conducting hydrogeological observations and measurements in few drill holes of special purposes, and equipping them with necessary devices testing 1-2 aquifers. And exploration boreholes are tested with hydrogeological uplift tests.

For the deposits of medium level and complicated hydrogeological conditions: hydrogeological surveys will be conducted in some special hydrogeological boreholes, and water out pumping tests and hydrogeological measurements are taken on 2 to 3 aquifers, determining water level decrease and recovery for several times. In addition, survey on hydrogeological condition of the deposit is undertaken in coupled way including excavation works and boreholes, and hydrogeological observation and measurements in short and long term.

5.2. Engineering-geological surveys of the deposit are carried out in accordance with the methodological recommendations for conducting "engineering-geological, hydrogeological and geoecological surveys during exploration and operation of the deposit" and the norms and rules of the "General Principles of Engineering surveys of Buildings and Structures (BNB 11-07-19). 2019".

Researches of Engineering-geological condition (open pits, underground excavation, basic mining calculations, drilling and blasting calculations, calculations of devices for underground workings, etc.) at deposits are completing necessary information for the mining project development and processing operational project of certain deposit. In results of the research on the engineering-geological condition of the deposit, it has to solve following items:

- Determining engineering-geological conditions for mining operation works;
- Selection of operation method (open and uncovered), and in the case operating underground mining, thus operation system has to be chosen;
- Estimation, optimization and selection of basic parameters of the mine;
- Studying and evaluating the natural factors that can affecting negatively the mining excavation; and
- Calculating waste and pollutants that will be appeared during mining.

5.2.1. The extraction of chrome ore deposits can be carried out using a combination of open and underground methods, each of which has different engineering and geological conditions.

In the studies of overburden that for open pit mining operation, properties of ore-bearing rocks will be in priority.

If deposit and ore bodies are hosted with weakly cemented rocks and loose sediments, covered with them, lithological composition, grain-size composition, degree of cementation, volume weight and specific weight, degree of porosity, moisture content, permeability coefficient and angle of natural stability.

If deposit and ore bodies are hosted with weakly cemented rocks and loose sediments, covered with them, the engineering-geological survey of these rocks will determine rock lithological composition, grain-size composition, degree of cementation, volume weight and specific weight, degree of porosity, moisture content, permeability coefficient and angle of natural stability.

In case of presence of permafrost, it can have been melted during mining operation and causing difficulties to mining conditions. Therefore, in regions with the development of permafrost, beside engineering-geological survey conducting to excavation works and boreholes, it shall be conducted measurement of temperature regime of rocks, geothermal survey, sampling frozen and melted soils in specified boreholes and excavation works and dispatching them to laboratory, determining contour of frost. In results of these studies, the following issues will be determined:

- distribution and location of the permafrost area, and thickness of permafrost soil, upper and lower boundary of the permafrost, location of the thaw area;
- the runoff water on the surface and down in bottom of permafrost;
- stability of the pit walls and bottom rocks;
- determining presence of karst caves, and contouring areas with risks of glider, the collapse, and suffusion or internal erosion process;
- impacts on surface runoff into mine.
- plan and implement water drainage, mine dewatering and other protective measures; and
- determine the location of the waste dump.

5.2.2. Exploration boreholes for engineering geological surveys and special boreholes drilled for this purpose will also be subjected to ordinary geological logging and following survey items:

- in hard and semi-hard rocks, studying hardness, strength, layering, schistosity, texture features, fractures (frequencies and direction of fractures, dipping angles, etc.), whether there is a characteristic of karst in rocks, filling materials of fracture and karsts. This kind rocks will be subjected to determination in the laboratory conditions, like as the petrographic composition, including the volume and specific weight, porosity, stability coefficient, resistance to one axial compression and disjunctive faults;

- in weakly cemented rocks, determination of consistency condition, texture feature, and other impurities of weakly cemented rocks in field survey; and in same time natural moisture content, volume weight, plasticity limits of the rocks in the laboratory conditions. And determination of density, plasticity resistance, porosity, water absorbing speeds, grain-sizes, water saturation, swelling and resistance to one axial compression and water content. And in same time,
- in loose sediments or non-cemented sediments, determination of grain-size composition and angle of natural stability. in addition, it shall be determined lithology and mineralogy composition, volume and specific weight, porosity, moisture content, water saturation and permeability coefficient in few samples; and
- in permafrost areas, the sampling will be taken from frozen and thaw rocks, determining summary moisture, ice content, volume and specific weight, and compressional resistivity of transit condition from frozen condition to thaw condition.

5.2.3. It has to delineate contour of the collapse zone in case of underground mining exploitation, determining locations of planned underground tunneling, choosing the method penetration and fixing the underground shafts, selecting choice of the optimal system for ore extraction and determining the size of protection rock mass on the background of the engineering - geological survey.

And it will have been important collecting information to determine the value of mountain pressure and rock movement during exploration on and area that belonged to underground exploitation of the deposit. The mountain pressure and rock movements are directly depending on the following factors:

- shape, size, interaction and location of the excavation works;
- geological factors such as thickness of the orebody, its stability, dipping angle, habit of host rock’s location, condition of tectonic faults, cleavages and schistose condition
- parameters, such as re-loads, hydrostatic pressure, and gaseous pressure on rocks that located in different depths; and
- physical and mechanical properties of the rocks.

If there are aquifers in roof rock or in basements of the excavating works (tunneling), it has to leave protective screen rocks (shield) against flooding shaft (or adit) tunnels; in addition, the rocks of the protective screens have to be tested (measurements of resistance to stretches).

5.4. Baseline studies (Environmental studies) are an integral part of the exploration project, including impacts that will have been observed in environment of the study area during exploration works on deposits and future mining operation, pre-planning the procedures preventing negative impacts to the area.

A systematic study of the impacts from the first stage of the deposit exploration to the surroundings creates an opportunity to plan activities for the next phase of exploration and for the purpose of outlining and mitigating the impacts from mining operations on the environment. Consequently, the amount of funds required for the study and implementation of environmental protection and environmental mitigation measures will be required to be planned and implemented in an economic assessment of the deposit.

5.4.1. For the baseline studies that related to evaluation of impact to the environment of the area caused by deposit exploration and future mining operation, it should be including following items:

1.1. Background parameters of the environment; the study will be conducted in the initial stages level, and its output is used for comparative basic parameters related to norms of impact parameters into the environment in future exploitation activities. The environmental baseline study shall determine initial status of atmosphere, surface water and groundwater, vegetation, soil cover, overburden, and geochemical basic characteristics of air, hydro system, soil, baseline assessment of radiation in them and other basic parameters.

1.2. research on impacts from the construction of mining facilities, and activities of exploitation and ore-processing works to the surrounding area;

The study on impacts to the surrounding area will be derived from the above-mentioned activities, are including following surveys of chemical and physical effects; especially dusting of adjacent areas, radiation and possible distribution of hazardous and toxic elements like as Hg, Pb, Zn, As, Cd, Se, Cu, Cr, V and others; and accumulating condition of them, pollution of atmosphere, surface water and ground water, soil and vegetation cover; and their size, dynamics and contours; polluting factors deriving from drainage water from mine and industrial liquid wastes, damage volumes of rock and ore transport to soil and vegetation cover, volume of withdrawal for needs of mining operation and effecting to forest areas and construction raw materials, water for technical needs, and lands for placement of the main and auxiliary productions; and their character, intensity, degree and danger of influence to surrounding area.

There have to be selected areas for mine site and construction of mine village; and determined the extent of the impact on the environment surrounding the future mine site and the construction of the mine villages and the storage of waste dump.

From the long-term storage of the waste dump, its surface part may be decayed due to atmospheric precipitation forming dust in the surroundings; and sulfuric solution containing heavy and toxic substances can be released due to dissolution of sulfides, whose impacts may be the most dangerous in the surroundings. Therefore, it is necessary to develop and maintain technologies for a waste storage and protection of environment based on the estimation of the impact of mine waste on the environment.

5.4.2. It has to investigate possibility of recycling of mine water in production operations, determining content of chemical compounds and elements in the mine water and identifying ways to prevent mixtures of contaminated water from natural water resource.

5.4.3. Mine re-cultivation is essential for environmental protection. In addition to surface recovery or technical re-cultivation, is the most important the biological recovery. Therefore, as soon as the mining begins, the humous soil stockpiles will be stored separately and kept in a special condition keeping its quality and will be used for later biological reclamation. The thin humous soils that are formed in the steppe and Gobi zones during geological timeline, are quite sensitive, therefore, the soil is being very important to protect, store and recovery the surface.

5.4.4. Other minerals that form independent deposits in the hosting and overlying rocks should be studied to the extent that allows determining their commercial value and area of possible use in accordance with the "Recommendations for the integrated study of deposits and the calculation of reserves of associated minerals and components". If this kind of study has not been developed yet, similar recommendation are being processed and used in other countries, specifically Russian, “Recommendation on comprehensive study of deposits and calculation of reserves of associated minerals and components, 2007” can be used for this purpose.

5.4.5. During the geological exploration of the deposit, the study for archeological, historical monuments and paleontological findings within the boundary of open pit of the future mining and processing industry, licensed area and its contour should be carried out by professional organizations in accordance with the procedures and requirements of Mongolian “Protection of the Cultural Heritage” legislation.

5.5. Hydrogeology, engineering-geology, geocryology, mining-geology and other natural conditions of the mining period shall be studied using geological, geophysical and other methods with sufficient accuracy to provide the initial information required for the development of the deposit. In the case of highly complex hydrogeology, engineering-geology and other natural conditions during mining, special work may be carried out in accordance with applicable regulations.

Six. Ore reserve estimation and resource evaluation

6.1. Reserve estimation and resource evaluation on chromium ore deposit have to be completed in accordance to the requirements of the “Classification and guideline of mineral resources and reserves of deposits” approved by order No. 278 of the Minister of Mining and Heavy Industry of September 11th, 2015.

6.2. This Recommendation classified deposit reserves into geological and production ones depending on the factors affecting the reserves of the deposit. The geological reserves are estimated on background of the exploration results, whereas the production reserves are calculated based on the feasibility study of the deposit.

6.3. The deposits’ geological reserves are divided into proved, measured, and indicated classifications, which are labeled as Proved is "A", measured is “B” and Indicated is "C".

6.4. The Proved (A) category reserve shall fully meet the requirements for the Proved (A) category reserves specified in the “Classification and guideline of mineral resources and reserves of deposits” of Mongolia. The contour of the Proved (A) category reserves should be drawn only along exploration workings and boreholes without extrapolation.

The Proved (A) category reserve is calculated at the developed deposits according to the data of exploitation exploration and mining developments. These include reserves prepared or ready for extraction of blocks that meet the requirements of the Classification for this category in terms of the degree of exploration.

As a result of the exploration work, the amount of the Proved (A) category reserves in Group II deposits will be sufficient to cover the initial investment of the extractive industry.

6.5. The Measured (B) class reserve is calculated in an area of the 2nd and 3rd groups of deposits subjected their detailed study area. Boundary of the reserve blocks shall be bordered with line connecting excavation workings and boreholes.

On the basis of detailed studies on the basic parameters like as thickness ranges of the ore-bodies and distribution pattern of major useful components, as well as identification of mining-geological condition, the border of blocks belonging to the Measured (B) classification can be contoured within frame of limited extrapolation. Also, it can be considered as Measured (B) class, if the part of the deposit locating under operation has been getting prepared or ready for mining excavation in results of completing exploration and mining excavation works. In addition, the Measured (B) class reserves are stated in accordance to the requirements of (B) class reserves prescribed in "Classification and guideline of mineral resources and reserves of deposits" that practiced in Mongolia. Based on exploration results, the estimated Measured (B) class reserve of the deposit has to be sufficient reserves to cover the initial investment of the mining enterprise. In case of 2nd group of deposit, major part of the reserves shall be estimated in Measured (B) classification.

6.6. The Indicated (C) class reserves are estimated in that part of deposit, where the exploration grid density allowed meeting the requirements to estimate the reserves in C-classification. For the area of the deposit that subjected to reserve estimation in Indicated (C) classification, the geological information and results have to be confirmed by the result of the detailed survey of the deposit, and for the mine operation area - by the results of exploitation of the deposit. In addition, boundary of area that subjected to reserve estimation in Indicated (C) class can be configured out along with lines connecting data of exploration workings and boreholes, and extrapolation lines taking in account the data of geological setting, morphology changes and geophysical survey of deposit.

The Indicated (C) class reserves are estimated in accordance to the requirements of (C) class reserves prescribed in "Classification and guideline of mineral resources and reserves of deposits" that practiced in Mongolia.

In case of 3rd group of deposit, major part of the reserves shall be estimated in Indicated (C) classification.

6.7. Identified resource (P1) for the deposit is evaluated on an area that revealed in few excavation workings and boreholes, and marginal and deep located parts in adjacent to the reserve estimated area in C-classification.

And boundary of area that subjected to evaluation of identified resource (P_1) class can be configured out along with exploration grid allowing reserve estimation in Indicated (C) class, or along with exploration grid allowing reserve estimation in C-classification or in sparser grid than the grid for resource evaluation of C-classification.

6.8 Feasibility study for mining operation of the deposit will be processed on background of the geological reserves. In results of the feasibility study completion, part of the geological reserves located within frame of the deposit and remaining after dedication of mining waste and pollution is presenting the production reserves, which is divided into Proved (A’) and Probable (B’) reserves according to requirements of “Classification and guideline of mineral resources and reserves of deposits”.

Proved (A’) production reserve is based on the geological reserves of mineral resources of Proved (A) and Measured (B) classifications; and on background of pilot test results selecting mining technics and technology, relevant assessments and ore technology features; and defined in details the engineering solutions, environmental and occupational safety taking in account hygiene, rights, human resources, management organizational structure, supply infrastructure, social and economic services, and economic efficiency calculations and related factors in accordance to "Feasibility study for deposit exploitation of mineral resources".

Probable (B’) production reserve is based on geological reserves of mineral resources of Measured (B) and Indicated (C) classifications; and on background of pilot test results selecting mining technics and technology, relevant assessments and ore technology features; and defined in details the engineering solutions, environmental and occupational safety taking in account hygiene, rights, human resources, management organizational structure, supply infrastructure, social and economic services, and economic efficiency calculations and related factors in accordance to "Feasibility study for deposit exploitation of mineral resources".

6.9. The requirements for production resources of the above mentioned 2 classifications are essentially the same, and the differences are observed in that the Proved (A ') production reserves based on geological reserves of Proved (A) and Measured (B) classes, while Probable (B’) production reserve – on geological reserves of Measured (B) and Indicated (C) classes.

6.10. The reserves are calculated by blocks, which have been configured out on the background of complexity of the deposit and study level the geological exploration works. The block units of deposits and ore-bodies for reserve estimation are characterized by following items:

I. the same degree of exploration parameters and study level determining the quantity and quality of mineral resources;
II. homogeneity of the geological structure or approximately the same or similar degree of variability in the thickness, internal structure of the ore bodies, the ore composition, the main indicators of the quality and technological properties of the ore;
III. stability of ore-body positions, the reserve blocks of the ore bodies located in the same structural element (on the same limb or in core of fold, or in same tectonic block, limited by faults); and
IV. common mining and technology conditions of operation.

6.11. Sometimes, it comes impossible to use the above-mentioned standards for definition of reserve blocks in traditional way. At reserve estimation using sectional method, the unit blocks for reserves estimation are made between two parallel exploration profiles. In this case, it is not possible to define properly the form of geological setting of the deposit, changes in distribution features of useful components and thickness of ore bodies, and differences between ore types and varieties of the mineral resource, revealing all of specifics of the above-mentioned characteristics. Thus, reserve estimations have to be made with at least 2 methods, and comparing summary shall be done for the deposit.

6.12. In geostatistical approach to reserve estimation, deposits and ore bodies are divided into micro blocks (micro units) based on minimal size of operation blocks for future operation and selective operation, technical characteristics of mining equipment in accordance to the standards for reserve estimation. This kind of relatively small sized micro-blocks can reflect precisely the changes related to geological setting and ore-mineralization features, allowing to distinguish micro blocks having homogenous parameters in the ore-bodies. However, the vast majority of such micro-blocks (i.e. the content of useful components) are data set up reserve parameters that configured by geostatistical calculations, such as kriging and neighboring methods rather than actual measurement. Therefore, it is important to note that the reserve classification guidelines of Russian and Commonwealth of Independent States (CIS) have recommended ensuring that such micro-blocks have to be sized not less than 1/4 of the average density of the exploration grid that set up on the deposit.

The utility of geo-statistical method is sensitive to geological setting feature of certain deposit, its distribution pattern of useful components, thickness, spatial position, size of the ore bodies, ore structure, size of the spatial distribution of the mineral resources, and geological and structural boundaries affecting to distinguish block units for reserve estimation; and size of the data, its quality, determination of spatial distribution pattern of the data (distribution law), and trends of data changes in the special distribution of the deposit, evaluation of anisotropic features, parameter-selection of search ellipsoid.

In reserve estimation via geo-statistical method, it is defined that links between data (contents of useful components, thickness of the ore body, content value of meter-percent, which is resulted by multiples of content and thickness of the ore-body) are stated with variograms and optimal selection of data interpolations methods (kriging, Nearest-neighbor interpolation, inverse distance weighting etc.). When constructing ore deposit's spatial models (sections and plan maps of layers) are assumed to be tens of data according to strike and dipping directions (or to strike and in cross direction to the strike) of the orebody, and in three-dimension model – hundreds of data along with thickness of the ore-bodies.

6.13. Reserves are calculated separately by reserve classifications and/or mining levels, (if operating with open pit), industrial (technological) types and grades of ores, their economic value, and geological and productive reserves of mineral reserves taking in account future mining methods.

In case of exploiting deposit, the reserves are distinguished on the background of exploration results and exploitation's exploration data, into such kind of reserves: prepared to exploitation, exhausted or extracted, left in protection pillars, left ores below village or town facilities, mine villages or water reservoirs, and reserves that will not exploited due to legal reason, environmental protection, and other factors that influence the exploitation.

6.14. The report including reserve estimation of mineral resources has to be completed in accordance to "Content of the Exploration Report Results of Mineral Resources and Its

Requirements" that submitted by order No. 414 of Director of MRAM on September 9th, 2009 and "Procedures for conducting of the prospecting, exploration and mining works on mineral resources" that approved by order No. A/20 of Minister of Mining and Heavy Industry of 2018.

Seven. Study degree of deposit

According to the “Guideline for classification of mineral resources and deposits’ reserves” approved by Mining Minister Order # 203 dated on September 15, 2015, the deposit of mineral resource (in the case of large deposits, some of their areas) can be classified into evaluated deposits and explored deposits.

- Evaluated deposit
- Explored deposit

7.1. The evaluated deposit is that kind of deposit, where it has been studied its geological setting and size, quality and technological feature of the mineral resource, hydrogeology, engineering geology and mining conditions with completeness sufficient to further exploration work as well as that has been assessed for industrial significance.

In the prospecting-evaluating works on the deposit, the study has to be conducted in level of the following requirements:

-For the evaluating deposit, Industrial type of mineral resource and significance should be determined, genesis of ore-mineralization, and shape and size of ore body should be assessed; potential parts should be distinguished and justification for further exploration work should be produced.

-determination of basic geological setting and size of the deposit and ore body of the assessment of mineral resource in identified resource (P_1) classification; reserve estimation of mineral resources is calculated on Indicated (C) classification within frame of studied area in details.

-material composition and technological properties of industrial types and minerals are studied with detail, providing basic data sufficient to design a rational processing technology with complex extraction of all useful components of industrial importance;

- hydrogeological, engineering-geological, geo-ecological, mining-geological and other natural conditions are studied in detail, providing the source data of their major parameters;

- selection of reserve estimation standards based on preliminary feasibility studies based on feasibility studies, or comparing data of deposits having similarities in geological setting and mining conditions to the studying deposit;

-selection of exploitation mode and system and volume of the exploitation are stated overviewing the volume of mining operation having similarities to the studying deposit;

-The water supply issue for the mine's industrial and domestic needs during the mining operation should be assessed based on information from local hydrogeological surveys, and water points located close to the deposit identified by the deposit's prospecting-evaluation work.

- Determining and evaluating environmental impacts associated with mining operation to the environment.

7.2. For a detailed study of the morphology, size and position of the ore bodies, and a development of technological schemes for the beneficiation and processing of ores at areas that are representative and explored in detail, where experts are working on conclusion, it can be carried out experimental-production mining operation to the areas, according to recommendation of the experts.

The experimental-production mining operation may have been carried out within the framework of a project of the exploration stage based on permission of state supervisions on mining and environmental issues.

The conduct of experimental-production mining operation is usually dictated by the need to identify the features of the geological structure of ore bodies, clarifying geological and mining conditions, configuring out ore mining technology, ore-enrichment and processing methods in case of necessity to additional survey for selection of optimal regime of the development.

In addition, the experimental-production mining operation will be applied to deposits with new and unique types of ore and new mining technologies in terms of ore processing procedures and processing technology prior to the establishment of a mining complex to mine large deposits.

7.3. On the explored deposits the quality and quantity of reserves, their technological properties, hydrogeological, geotechnical and mining conditions and other parameters required for reserve estimation should be studied with boreholes and excavating works (open and underground) with completeness sufficient to develop a feasibility study of the decision on the procedure and conditions of their involvement in industrial (mining) development, as well as the design of construction or reconstruction on their basis of mining exploitation.

The explored deposits of chromium should meet the following requirements according to the degree of study:

- Chromium deposits should be classified according to the relevant group of complexity of the geological settings of the deposit specified in this recommendation, and the geological resources of the deposit shall be calculated based on the feasibility study and classified according to the conditional parameters set by the relevant criteria.
- The authorized professional author and the expert shall review and confirm the deposit’s optimal reserve ratio calculated in various classifications that based on the specialties of the deposit's geological setting and the investment conditions of construction of mining and ore-dressing enterprises.
- The shape and size of the ore body and geological settings of the deposit should be studied and confirmed as detail as possible, and the ore reserves of the deposit shall be calculated by Measured (B) category in the explored areas and Indicated (C) category in other areas. The measured (B) category reserve shall not be less than 30.0% of the total reserves.

- The result of the ore quality study should be sufficient for providing the initial data for the design of optimal technology of their processing with a complex extraction of all mineral components of industrial importance, and determining the direction of use of waste or the optimal variant of their storage or to bury them.
- Comprehensive study of the deposit shall be conducted, it should be estimated the reserves of accompanying mineral resources and determined volume of removing overburden and possible directions of use of groundwater.
- Obtained information by studying hydrogeology, engineering geology, geo-ecology, mining and other conditions of the deposit shall meet the requirements of the legislation related to environmental protection, mine safety as well as feasibility study for mining and processing plant.
- Geological settings, quality and quantity of mineral resources, distribution of useful component and structure of ore body should be studied in detail at the representative area of the deposit selected on the basis of geological settings.
- The calculation parameters of the conditions are established on the basis of technical and economic calculations that allow determining the scale and industrial significance of the deposit with the necessary degree of reliability.
- For the deposits that located in vicinity to each other or same ore-bearing district, and having similar genesis and geological settings, standards of reserve estimation can be accepted on analogy way, but it has to have a good reason.
- Consideration about possible impact of the deposit exploitation and ore-dressing works on the environment is considered and recommendations are given to prevent or reduce the predicted level of negative environmental consequences to the requirements of the relevant regulations.

7.4. The geological reserves and productive reserves, and feasibility study of the deposit that has been explored corresponding to the above-mentioned requirements, shall be passed through and registered by Mineral Resources Professional Council of Mongolia.

Eight. Re-estimation and registration of deposit reserves

8.1. Re-estimation and re-approval of reserves in accordance with the established procedure is carried out at the initiative of the subsoil user, as well as control and supervisory organizations in cases of a significant change in ideas about the quality and quantity of reserves of the deposit and its geological and economic assessment as a result of additional exploration and mining operations.

8.2. At the initiative of the owners of exploration and exploitation procedures, re-estimation and re-approval of reserves is carried out to the deposit taking into account following cases:

- substantial non-confirmation of explored and previously approved reserves and (or) their quality, differing greater than 20%;
- objective, substantial (more than 20%) and a steady fall in the price of products while maintaining the level of production costs;
- changing industry requirements for the quality of mineral raw materials; and
- change is observed in the previously identified reserve classification during exploration works.

8.3. At the initiative of the government and supervisory organizations, re-estimation and re-approval of reserves is carried out to the deposit taking into account following cases:

- Increase in deposit’s reserves, compared with previously approved (or registered), more than 30%;
- Prices for extracted products have risen steadily by more than 30%
- Development and introduction of new technologies that significantly improve the economy of production;
- Identifying in the ores or host rocks, valuable components or harmful impurities that were not previously taken into account when assessing the deposit and designing the enterprise.

8.4. The rights of the license holder and the state have been violated, and the amount of tax to be imposed has been changed without justification.

8.5. The economic problems of the enterprise caused by temporary reasons such as geological, technological, hydrogeological and mining complications, a temporary drop in world prices for products are solved using the mechanism of operating conditions and do not require re-estimation and re-approval of reserves.

After the ore preparation operation, 0-160mm of the chromium ore to distinguish 0-10mm and 10-160mm by given to the sieve. Among them 10-160mm distinguished ore concentrate proceed on the heavy liquid equipment “Vedag”. Concentrates of the class of 10-160 mm are transported to the completed product warehouse.

All waste of the 10-160 mm class is transported to the semi-product storage and then to the sludge dump. The product under the grid of class 0-10 mm is divided into classes 0-3 mm and 3-10 mm and is enriched on a dosing machine. The above product with cells of class 3-10 mm is from the sieve into the OPS-24 dosing machine.

And concentrate for the dosing machine transported to completed product warehouse. The waste of concentrate for the dosing machine is extracting following three products of ore concentrate, semi-product and waste on the waste screw classifier equipment. Donskoy’s Ore processing plant-1 waste is transport to the sludge dumps or waste dam

Ore concentrate with low chromium content: There are many methods of chrome ore enrichment. One of the most common methods is flotation. Flotation has been used to produce chromium-containing materials since time immemorial. Sodium oleate is used for flotation collector; technical sodium and liquid glass is for used an environment adjuster and modifier.

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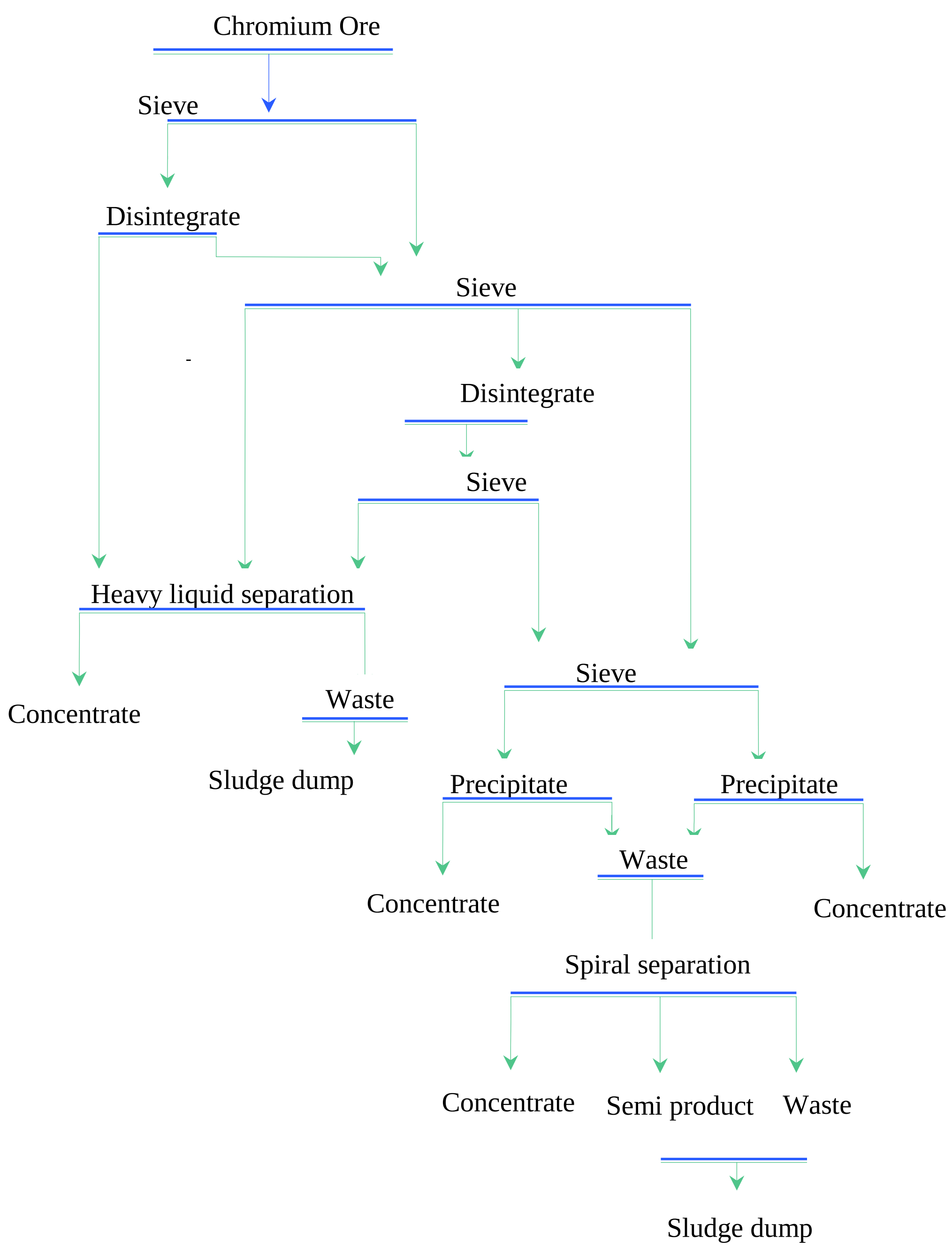
Ten. Appendix

SCHEME OF CHROME ORE PROCESSING TECHNOLOGY



Pigure-1. Scheme of DONSKOY'S ORE PROCESSING PLANT processing technology