Introduction to Databases on Significant Metalliferous and Selected Non-Metalliferous Lode Deposits, and Selected Placer Districts of Northeast Asia

By Sodov Ariunbileg[1], Gennandiy V. Biryul'kin[2], Jamba Byamba[3], Yury V. Davydov[3], Gunchin Dejidmaa[4], Elimir G. Distanov[5], Dangindorjiin Dorjgotov[3], Gennadiy N. Gamyanin[2], Ochir Gerel[6], Valeriy Yu. Fridovskiy[7], Ayurzana Gotovsuren[8], Duk Hwan Hwang[9], Anatoliy P. Kochnev[10], Alexei V. Kostin[2], Mikhail I. Kuzmin[11], Sergey A. Letunov[11], Jiliang Li[12], Xujun Li[12], Galina D. Malceva[10], V.D. Melnikov[2], Valeriy M. Nikitin[7], Alexander A. Obolenskiy[5], Masatsugu Ogasawara[13], Demberel Orolmaa[1], Leonid M. Parfenov[2], Nikolay V. Popov[5], Andrei V. Prokopiev[2], Vladimir Ratkin[14], Sergey M. Rodionov[15], Zhan V. Seminskiy[10], Vladimir I. Shpikerman[16], Alexander P. Smelov[2], Vitaly I. Sotnikov[5], Alexander V. Spiridonov[11], Valeriy V. Stogniy[7], Sadahisa Sudo[13], Fengyue Sun[12], Jiapeng Sun[12], Weizhi Sun[12], Valeriy M. Supletsov[10], Vladimir F. Timofeev[2], Oleg A. Tyan[2], Valeriy G. Vetluzhskikh[2], Aihua Xi[12], Yakov V. Yakovlev[2], Hongquan Yan[12], Vladimir I. Zhizhin[7], Nikolay N. Zinchuk[19], and Lydia M. Zorina[11]

Edited by Warren J. Nokleberg[158] and Tatiana V. Bounaeva[11], Robert J. Miller[15], and Zhan V. Seminskiy[10]

[1] Mongolian Academy of Sciences, Ulaanbaatar
[2] Russian Academy of Sciences, Yakutsk
[3] Mongolian National University, Ulaanbaatar
[4] Mineral Resources Authority of Mongolia, Ulaanbaatar
[5] Russian Academy of Sciences, Novosibirsk
[6] Mongolian University of Science and Technology, Ulaanbaatar
[7] Yakutian State University, Yakutsk
[8] Mongolia Ministry of Industry and Commerce, Ulaanbaatar
[9] Korean Institute of Geology, Mining, and Mineral Resources, Taejon
[10] Irkutsk State Technical University, Irkutsk
[11] Russian Academy of Sciences, Irkutsk
[12] Jilin University, Changchun
[13] Geological Survey of Japan/AIST, Tsukuba
[14] Russian Academy of Sciences, Vladivostok

[15] Russian Academy of Sciences, Khabarovsk
[16] Russian Academy of Sciences, Magadan
[15] Russian Academy of Sciences, Blagoveschensk
[19] ALROSA Joint Company, Mirnyi
[18] U.S. Geological Survey, Menlo Park

Introduction

This publication is a digital database compilation of the significant metalliferous and selected non-metalliferous lode deposits and placer districts of Northeast Asia. This region includes Eastern Siberia, Russian Far East, Mongolia, Northeast China, South Korea, and Japan. The report provides detailed summaries of the important features of the significant lode deposits and placer districts along with a summary of mineral deposit models, and lists of cited references. Data are provided herein for 1,674 significant lode deposits of the region and 91 placer districts for the region.

The databases for significant lode deposits and placer districts are given in the following files in the directory named DATABASE:

1. lode deposits.fp5 Lode deposit database for NE Asia in FileMaker Pro 5 format.
2. lode deposits.xls Lode deposit database for NE Asia in Excel format.
3. lode deposits.db4 Lode deposit database for NE Asia in dBase format.
4. lode deposits.doc Lode deposit database for NE Asia in Word format.
5. lode deposits.txt Lode deposit database for NE Asia in tab-delineated text format.
6. placer districts.fp5 Placer district database for NE Asia in FileMaker Pro 5 format.
7. placer districts.xls Placer district database for NE Asia in Excel format.
8. placer districts.db4 Placer district database for NE Asia in dBase format.
9. placer districts.doc Placer district database for NE Asia in Word format.
10. placer districts.txt Placer district database for NE Asia in tab-delineated text format.

On this CD-ROM, the databases for lode deposits and placer districts are sorted in order of map row, map column, and number in quadrant, as explained below. This sorting parallels the map showing locations of lode deposits and placer districts. The databases be resorted according to the wishes of the user and capabilities of the database and other programs.

The complete references for the databases are given in the following files in the directory named TEXT FILES.

1. lode references.doc References for NE Asia lode deposits in Word format.
2. placer references.doc References for NE Asia lode placer districts in Word format.

The directory named LOCATION contains a map in Adobe Acrobat PDF format that shows the locations of the lode deposits and placer districts at a scale of 1:7,500,000. The base for the map is a simplified version of a Northeast Asia Geodynamics Map that is published separately.

These databases are prepared by a large group of Russian, Chinese, Mongolian, South Korean, Japanese, and USA geologists who are members of the joint international project on *Major Mineral Deposits, Metallogenesis, and Tectonics of Northeast Asia*. This project is being conducted by the Russian Academy of Sciences, the Mongolian Academy of Sciences, Mongolian National University, Ulaanbaatar, Mongolian Technical University, the Mineral Resources Authority of Mongolia, Geological Research Institute, Jilin University, China Geological Survey, Korea Institute of Geoscience and Mineral Resources, the Geological Survey of Japan, and the U.S. Geological Survey. Information about major goals and pubications for this project is available at the USGS Internet/Web site at http://minerals.usgs.gov/west/projects/minres.html.
This report is published in digital format on a CD-ROM. This report is one of a series of studies on the mineral deposits, metallogenic belts, bedrock geology, and tectonics of the Northeast Asia. This report is one of a series of reports on the mineral resources, metallogenesis, geodynamics, and metallogenesis of the region.

Metallogenic, Tectonic, Alteration, and Specialized Rock Name Definitions

The following key definitions are provided.

Aleurolite. Siltstone.

Beresite. A greisen or altered rock with quartz, sericite, carbonate (mainly ankerite), and pyrite.

Deposit. A general term for any lode or placer mineral occurrence, mineral deposit, prospect, and (or) mine.

Listvenite. An altered rock with quartz, fuchsite (Cr

mica), chlorite, sericite, and carbonate (mainly magnesite and breunnerite).

Metallogenic belt. A geologic unit (area) that either contains or is favorable for a group of coeval and genetically-related, significant lode deposit models.

Metasomatite. A rock whose chemical composition is substantially changed by metasomatic alteration of original constutents. Examples are skarn and hydrothermally-altered rock..

Mine. A site where valuable minerals have been extracted.

Mineral deposit. A site where concentrations of potentially valuable minerals for which grade and tonnage estimates have been made.

Mineral occurrence. A site of potentially valuable minerals on which no visible exploration has occurred, or for which no grade and tonnage estimates have been made.

Overlap assemblage. A postaccretion unit of sedimentary or igneous rocks deposited on, or intruded into, two or more adjacent terranes (Jones and others, 1983; Howell and others, 1985; Nokleberg and others, 2000). The sedimentary and volcanic parts either depositionally overlie, or are interpreted to have originally depositionally overlain, two or more adjacent terranes, or terranes and the craton margin. Overlapping plutonic rocks, which may be coeval and genetically related to overlap volcanic rocks, link or stitch together adjacent terranes, or a terrane and a craton margin.

Prospect. A site of potentially valuable minerals in which excavation has occurred.

Secondary quartzite. A metasomatic quartz-rich rock formed during hydrothermal alteration or supergene alteration associated with porphyry Cu or Mo deposits.

Significant mineral deposit. A mine, mineral deposit, prospect, or occurrence that is judged as important in the metallogenesis of a geographic region.

Terrane. A fault-bounded geologic entity or fragment that is characterized by a distinctive geologic history that differs markedly from that of adjacent terranes (Jones and others, 1983; Howell and others, 1985; Nokleberg and others, 2000). Constitutes a physical entity, i.e., a stratigraphic succession bounded by faults, inferred faults, or an intensely-deformed structural complex bounded by faults. Some terranes may be displaced (faulted) facies of other terranes.

Lode and Placer Mineral Deposit Models

For description and classification, lode mineral and placer deposits are classified into various models or types. Detailed descriptions are provided in the companion paper by Obolenskiy and others on this CD-ROM. The following principles are employed for synthesis of mineral deposit models for this study. (1) Deposit forming processes are closely related to rock-forming processes (Obruchev, 1928). (2) Mineral deposits originate as the result of mineral mass differentiation in sedimentary, magmatic, and metamorphic circles of formation of rocks and geological structures (Smirnov, 1969). And (3) the classification is easily understood, and open so that new types of the deposits can be added (Cox and Singer, 1986).

In this classification for this study, lode deposits are grouped into the hierarchic levels of metallogenic taxons according to such their stable features as: (a) environment of formation of host and genetically-related rocks, (b) genetic features of the deposit, and (c) mineral and (or) elemental composition of the ore. The six hierarchial levels are as follows.

Group of deposits
  Class of deposits
    Clan of deposits
      Deposit types (models)

The deposit models are subdivided into the following four large groups according to major geological rock-forming processes: (1) deposits related to magmatic processes; (2) deposits related to hydrothermal-sedimentary processes; (3) deposits related to metamorphic processes; (4) deposits related to surficial processes and (5) exotic deposits. Each group includes several classes. For example, the group of deposits related to magmatic processes includes two classes: (1) those related to intrusive rocks; and (2) those related to extrusive rocks. Each class includes several clans, and so on. The most detailed subdivisions are for magmatic-related deposits because they are the most abundant in the project area. In the below classification, lode deposit types models that share a similar origin, such as magnesian and (or) calcic skarns, or porphyry deposits, are grouped together under a single genus with several types (or species) within the genus.

.

Table 1. Hierarchial ranking of mineral deposit models.

Deposits related to magmatic processes
  Deposits related to intrusive magmatic rocks
    I. Deposits related to mafic and ultramafic intrusions
      A. Deposits associated with differentiated mafic-ultramafic complexes
        Mafic-ultramafic related Cu-Ni-PGE
        Mafic-ultramafic related Ti-Fe (±V)
        Zoned mafic-ultramafic Cr-PGE

- B. Deposits associated with ophiolitic complexes
  - Podiform chromite
  - Serpentinite-hosted asbestos
- C. Deposits associated with anorthosite complexes
  - Anorthosite apatite-Ti-Fe-P
- D. Deposits associated with kimberlite
  - Diamond-bearing kimberlite

II. Deposits related to intermediate and felsic intrusions

- A. Pegmatite
  - Muscovite pegmatite
  - REE-Li pegmatite
- B. Greisen and quartz vein
  - Fluorite greisen
  - Sn-W greisen, stockwork, and quartz vein
  - W-Mo-Be greisen, stockwork, and quartz vein
- C. Alkaline metasomatite
  - Ta-Nb-REE alkaline metasomatite
- D. Skarn (contact metasomatic)
  - Au skarn
  - Boron (datolite) skarn
  - Carbonate-hosted asbestos
  - Co skarn
  - Cu (±Fe, Au, Ag, Mo) skarn
  - Fe skarn
  - Fe-Zn skarn
  - Sn skarn
  - Sn-B (Fe) skarn (ludwigite)
  - W±Mo±Be skarn
  - Zn-Pb (±Ag, Cu) skarn
- E. Porphyry and granitoid pluton-hosted deposit
  - Cassiterite-sulfide-silicate vein and stockwork
  - Felsic plutonic U-REE
  - Granitoid-related Au vein
  - Polymetallic Pb-Zn ± Cu (±Ag, Au) vein and stockwork
  - Porphyry Au
  - Porphyry Cu (±Au)
  - Porphyry Cu-Mo (±Au, Ag)
  - Porphyry Mo (±W, Bi)
  - Porphyry Sn

III. Deposits related to alkaline intrusions

- A. Carbonatite-related deposits
  - Apatite carbonatite
  - Fe-REE carbonatite
  - Fe-Ti (±Ta, Nb, Fe,Cu, apatite) carbonatite
  - Phlogopite carbonatite
  - REE (±Ta, Nb, Fe) carbonatite
- B. Alkaline-silicic intrusions related deposits
  - Alkaline complex-hosted Au
  - Peralkaline granitoid-related Nb-Zr-REE
  - Albite syenite-related REE
  - Ta-Li ongonite
- C. Alkaline-gabbroic intrusion-related deposits
  - Charoite metasomatite
  - Magmatic and metasomatic apatite
  - Magmatic graphite
  - Magmatic nepheline

Deposits related to extrusive rocks

IV. Deposits related to marine extrusive rocks

- A. Massive sulfide deposits
  - Besshi Cu-Zn-Ag massive sulfide
  - Cyprus Cu-Zn massive sulfide
  - Korean Pb-Zn massive sulfide
  - Volcanogenic Cu-Zn massive sulfide (Urals type)
  - Volcanogenic Zn-Pb-Cu massive sulfide (Kuroko, Altai types)
- B. Volcanogenic-sedimentary deposits
  - Volcanogenic-hydrothermal-sedimentary massive sulfide Pb-Zn (±Cu)
  - Volcanogenic-sedimentary Fe
  - Volcanogenic-sedimentary Mn

V. Deposits related to subaerial extrusive rocks
A. Deposits associated with mafic extrusive rocks and dike complexes
Ag-Sb vein
Basaltic native Cu (Lake Superior type)
Hg-Sb-W vein and stockwork
Hydrothermal Iceland spar
Ni-Co arsenide vein
Silica-carbonate (listvenite) Hg
Trap related Fe skarn (Angara-Ilim type)
B. Deposits associated with felsic to intermediate extrusive rocks
Au-Ag epithermal vein
Ag-Pb epithermal vein
Au potassium metasomatite (Kuranakh type)
Barite vein
Be tuff
Carbonate-hosted As-Au metasomatite
Carbonate-hosted fluorspar
Carbonate-hosted Hg-Sb
Clastic sediment-hosted Hg±Sb
Epithermal quartz-alunite
Fluorspar vein
Hydrothermal-sedimentary fluorite
Limonite from spring water
Mn vein
Polymetallic (Pb, Zn±Cu, Ba, Ag, Au) volcanic-hosted metasomatite
Polymetallic (Pb, Zn, Ag) carbonate-hosted metasomatite
Rhyolite-hosted Sn
Sulfur-sulfide (S, FeS_2)
Volcanic-hosted Au-base-metal metasomatite
Volcanic-hosted Hg
Volcanic-hosted U
Volcanic-hosted zeolite
Deposits related to hydrothermal-sedimentary sedimentary processes
VI. Stratiform and stratabound deposits
Bedded barite
Carbonate-hosted Pb-Zn (Mississippi valley type)
Sediment-hosted Cu
Sedimentary exhalative Pb-Zn (SEDEX)
VII. Sedimentary rock-hosted deposits
Chemical-sedimentary Fe-Mn
Evaporate halite
Evaporate sedimentary gypsum
Sedimentary bauxite
Sedimentary celestite
Sedimentary phosphate
Sedimentary Fe-V
Sedimentary siderite Fe
Stratiform Zr (Algama Type)
VIII. Polygenic carbonate-hosted deposits
Polygenic REE-Fe-Nb deposits (Bayan-Obo type)
Deposits related to metamorphic processes
IX. Sedimentary-metamorphic deposits
Banded iron formation (BIF, Algoma Fe)
Banded iron formation (BIF, Superior Fe)
Homestake Au
Sedimentary-metamorphic borate
Sedimentary-metamorphic magnesite
X. Deposits related to regionally metamorphosed rocks
Au in black shale
Au in shear zone and quartz vein
Clastic-sediment-hosted Sb-Au
Cu-Ag vein
Piezoquartz
Rhodusite asbestos
Talc (magnesite) replacement
Metamorphic graphite
Metamorphic sillimanite
Phlogopite skarn

Deposits related to surficial proceses
- XI. Residual deposts
  - Bauxite (karst type)
  - Laterite Ni
  - Weathering crust Mn (±Fe)
  - Weathering crust and karst phosphate
  - Weathering crust carbonatite REE-Zr-Nb-Li
- XII. Depositional deposits
  - Placer and paleoplacer Au
  - Placer diamond
  - Placer PGE
  - Placer Sn
  - Placer Ti-Zr
  - REE and Fe oolite

Exotic deposits
- Impact diamond

Descriptions of Headings for Tabular Descriptions for Significant Lode Deposits and Placer Districts

Map Number, Name, Major Metals

Map number refers to a specific deposit in a given region. Lode deposits and placer districts are numbered separately within individual quadrants bounded by integer values of 4° of latitude and 6° of longitude. The quadrants are numbered from west to east, and are lettered from south to north. A latitude and longitude location is stated for each deposit in degrees and minutes. Names of lode deposits are derived from published sources or common usage. In some cases, two deposits are grouped together and both names are given. In other cases, an alternate name is given in parentheses. Major metals are the known potentially valuable metals reported for each deposit, and are listed in order of decreasing abundance and (or) value, and are shown by standard chemical symbols.

Lode Deposit Type

Type of lode deposit, or lode deposit model is an interpretation that was made by examining the summary of the deposit and then classifying the deposit using the deposit models previously described. The type is queried where insufficient description precludes precise determination. For a few deposits, either the closest two deposit models are listed, or else a short description is given in parentheses.

Summary with References

The summary is a brief description of the major features of the deposit. Where known, the major economic minerals, gangue minerals, and the deposit form are stated. Form of deposit denotes the physical aspect of a deposit, whether, for example, a vein, disseminated mineral grains, or masses of minerals. Form is descriptive, and is distinct from genetic terms such as *contact metasomatic* or *volcanogenic*, which imply origin or history. Because lode deposits may be geologically complex, a deposit may contain more than one form, and certain forms may be gradational. Where known, estimates of tonnage and grade are listed, or else the terms small, medium, or large size, and low-, medium-, or high-grade are used. Tonnages are listed in tonnes (metric tons). Grades are stated either in weight percent (%), for abundant metals, or in grams per tonne (g/t) for scarce and precious metals. In many deposits, the only available information is on the grade(s) of grab samples. The metric system (SI) is used for all volume and weight measurements. If publicly known, the length, width, and depth of the deposit are stated. Additional information on the host rocks and their relation to the deposit are also stated. Information on extent of underground or surface workings and on the period of mining or development is given, if known. Sources of information, stated at the end of each summary, are the references and oral or written communications used to compile the data for each deposit. Unpublished data gathered expressly for this report are indicated by the terms *written communication* or *oral communication*.

Tabular Descriptions for Significant Placer Districts

Table headings for deposits in placer districts are described only for headings differing from those for lode deposits. District refers to the name of a group of geologically and geographically related placer deposits, as derived from published sources or from general usage. In some cases, two or more districts are grouped together and both names are given. In other cases, an alternate name is given in parentheses. Type refers to the placer deposit type as determined by examining the description of the district and then classifying using one of the deposit models described above. Economic and significant heavy minerals are reported for each district, listed in order of decreasing abundance.

Abbreviations in Tables

Standard chemical symbols: for example, Au, gold; Cu, copper; Fe, iron; U, uranium

PGE: Platinum-group elements--minerals and alloys

REE: Rare-earth elements
mm, cm, m, km: millimeter, centimeter, meter, kilometer
g, kg, t: gram, kilogram, metric ton
g/t, g/m^3: grams per metric ton, grams per cubic meter
tonne: metric ton
%: weight percent
sq: square

Conversion Factors for Tables

The following conversion factors were used to convert weight and volume from U.S. Customary to metric quantities:

1 cubic yard = 0.765 cubic meter
1 troy ounce per short ton = 34.29 grams per metric ton
1 part per million = 1 gram per metric ton
1 pound = 0.454 kilogram
1 troy ounce = 31.10 grams
1 short ton = 0.907 metric ton
1 flask (76.0 pounds mercury) = 34.7 kilograms

Tabular Descriptions for Sizes of Lode Deposits

Size categories for lode mineral deposits, adapted from Guild (1981), are listed below. These size categories define the terms *world class, large, medium, and small*. These size categories are used mainly in the parts of Table 1 on the lode deposits where specific tonnage and grade data are not yet available. The *small* category may include occurrences of unknown size. Units are metric tons of metal or mineral contained,
unless otherwise specified.

Table 2. Size categories for lode mineral deposits, adapted from Guild (1981).

Metal	World Class >	Large >	Medium >	< Small
Antimony		50,000	5,000	
Barite ($BaSO_4$)		5,000,000	50,000	
Chromium (Cr_2O_3)		1,000,000	10,000	
Cobalt		20,000	1,000	
Copper	5 million	1,000,000	50,000	
Gold		500	25	
Iron (ore)		100,000,000	5,000,000	
Lead	5 million	1,000,000	50,000	
Magnesium ($MgCO_3$)		10,000,000	100,000	
Manganese (tons of 40% Mn)		10,000,000	100,000	
Mercury (flasks)		500,000	10,000	
Molybdenum	500,000	200,000	5,000	
Nickel	1 million	500,000	25,000	
Niobium-Tantalum (R_20_5)		100,000	1,000	
Platinum group		500	25	
Pyrite (FeS_2)		20,000,000	200,000	
Rare earths (RE_20_3)		1,000,000	1,000	
Silver		10,000	500	
Tin		100,000	5,000	
Titanium ($Ti0_2$)		10,000,000	1,000,000	
Tungsten	30,000	10,000	500	
Vanadium	30,000	10,000	500	
Zinc	5 million	1,000,000	50,000	

ACKNOWLEDGMENTS

We thank the many geologists who have worked with us for their valuable expertise on the mineral deposits, geology, metallogenesis, and tectonics of Northeast Asia. We thank Russian interpreters Tatiana Bounaeva and Elena Koltunova for their skill and assistance during long and complex scientific dialogues, and for translation of complex geologic unit

and mineral deposit descriptions, and references. We also thank Dennis P. Cox and Jeff L. Doebrich for their constructive reviews.

REFERENCES CITED

Cox, D.P. and Singer, D.A., eds., 1986, Mineral deposit models: U.S. Geological Survey Bulletin 1693, 379 p.

Guild, P.W., 1981, Preliminary metallogenic map of North America: A numerical listing of deposits: U.S. Geological Survey Circular 858-A, 93 p.

Howell, D.G., Jones, D.L., and Schermer, E.R., 1985, Tectonostratigraphic terranes of the Circum-Pacific region: principles of terrane analysis, *in* Howell, D.G., ed., Tectonostratigraphic terranes of the Circum-Pacific region: Circum-Pacific Council for Energy and Mineral Resources, Earth Science Series, v. 1, p. 3-31.

Jones, D.L., Howell, D.G., Coney, P.J., and Monger, J.W.H., 1983, Recognition, character, and analysis of tectonostratigraphic terranes in western North America, *in* Hashimoto, M., and Uyeda, S., eds., Accretion tectonics in the circum-Pacific region: proceedings of the Oji International Seminar on Accretion Tectonics, Japan, 1981: Tokyo, Terra Scientific Publishing Co., Advances in Earth and Planetary Sciences, p. 21-35.

Nokleberg, W.J., Parfenov, L.M., Monger, J.W.H., Norton, I.O., Khanchuk, A.I., Stone, D.B., Scholl, D.W., and Fujita, K., 2000, Phanerozoic tectonic evolution of the Circum-North Pacific: U.S. Geological Survey Professional Paper 1626, 122 p.

Obruchev, V.V., 1928, Various investigations on ore deposit systematics: Journal of Mineralogy, Geology, and Paleontology, v. A., no. 4, p. 143-146 (in German).

Smirnov, V.I., 1969, Geology of useful minerals: Nedra, Moscow, 687 p. (in Russian).