GEOLOGICAL SURVEY OF CANADA

OPEN FILE 3792a

World distribution of porphyry, porphyry-associated skarn, and bulk-tonnage epithermal deposits and occurrences

Compiled by:
R.V. Kirkham, K.P.E. Dunne

2000

Natural Resources Canada Ressources naturelles Canada

Canada

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WORLD DISTRIBUTION OF PORPHYRY, PORPHYRY-ASSOCIATED SKARN, AND EPITHERMAL (BULK MINEABLE) DEPOSITS AND OCCURRENCES

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SUMMARY

The Porphyry, Porphyry-Associated Skarn, and Epithermal (Bulk Mineable) database is an index-level digital database designed for display of the following deposit and/or ore zone data on a map backdrop:

- morphologic and genetic type
- metal type
- contained metal(s) and size
- radiometric age
- petrochemical affinity
- tectonic setting

It was developed to assist the understanding of the distribution, geological setting, and genesis of porphyry and associated deposit types. It should be a useful guide to mineral exploration planning and mineral deposits research.

The database included with this report (on diskette) is an Access v.7.0 file. It is readily exportable to other database management systems.

The structure of the database consists of two levels:

- ORE ZONE: Concentration or zone of (ore) minerals individualized by form or character from adjoining country rock.
- DEPOSIT: Group of ore zones sometimes differing from each other in structure but interconnected or otherwise closely related genetically.

The database consists of data in four tables, a junction table and 15 lookup tables. The database contains information on 783 deposits and occurrences comprising 1022 ore zones in 62 countries. There are 1572 individual production and reserve figures on 508 deposits, and 886 radiometric age determinations on 339 deposits. A comprehensive reference list of 1320 references is linked to the database. The database is current to January 1998 although a number of more recent references are included.

INTRODUCTION

Porphyry deposits are the world's most important source of copper, molybdenum, and rhenium, and are major sources of gold, silver, and tin; other byproduct metals include tungsten, platinum, palladium, and selenium (Kirkham and Sinclair, 1996). They account for about 50 to 60% of world copper production and more than 99% of world molybdenum production and reserves (Kirkham and Sinclair, op. cit.). The porphyry, porphyry-associated skarn, and epithermal (bulk mineable) index-level digital database included in this report, was developed to better understand the distribution, geological setting, and genesis of porphyry and porphyry-associated deposit types. The general objectives of the database are to meet the research and exploration need for global porphyry information.

The porphyry, porphyry-associated skarn, and epithermal (bulk mineable) database was initiated in 1983 by R.V. Kirkham. The initial database structure was designed with the help of R. Laramée and D. Garson and approximately one quarter of the database was compiled intermittently and on a part-time basis between 1983 and 1994 as CUMOFILE by various workers including: R.V. Kirkham, A.G. Douma, J.J. Carrière, A. Galley, and K.V. Ross. Addition and upgrading of data and restructuring of the database were achieved by K.P. Dunne and R.V. Kirkham intermittently and on a part-time basis between August 1995 and

March 1998 with initial support by **Inmet Mining Corporation** (1995) and subsequent support by ten exploration companies under the World Map Project of the Geological Survey of Canada. These companies were **Anglo American Corporation, Barrick Gold Corporation, BHP Minerals Canada Ltd., Cyprus Amax Minerals Company, Falconbridge Limited, INCO Ltd., Noranda Exploration Company Limited, Placer Dome Exploration Inc., Rio Tinto Mining and Exploration Limited,** and **WMC International Limited**. The database was released to these companies in March 1998.

The objectives of the World Map Project porphyry & related deposits database subproject (August 1995-March 1998) were to:

- Restructure and modify CUMOFILE and a number of other existing GSC databases to a usable format for the porphyry, porphyry-associated skarn, and epithermal (bulk mineable) deposits and occurrences database using Microsoft Access.

- Review, compile, and digitally enter appropriate index-level, scientific and economic data current to December 1997 into the modified database.

- Prepare database documentation and a map illustrating world distribution of porphyry, porphyry-associated skarn, and epithermal (bulk mineable) deposits and occurrences by deposit classification, total metal content, and tenor to accompany the digital dataset.

Although the design and structure of the database has seen significant structural, design, and content upgrading since its inception in the early 1980s, some artifacts of the limited text handling capabilities of the original mainframe management system on which it was designed remain in this version of the database. These are:

- The basic table structure is perhaps oversimplified due to limitations in the original design.

- All data have been coded in capital letters.

- There are gaps in the unique reference key numbering of both deposits and references due to deletions and modification of data with time and availability of published data.

This report documents the description and design of the database to March 1998 and includes:

- a listing of the database content
- an explanation of the listing
- the entire data set on a diskette
- a map of porphyry and associated types of deposits at 1:35 000 000 scale

The porphyry, porphyry-associated skarn, and epithermal (bulk mineable) is currently being reformatted and upgraded as a subproject of the World Minerals Project of the Geological Survey of Canada managed by W.D. Sinclair. This project is sponsored at present by the following ten exploration companies: **Barrick Gold Corporation, Billiton SA Limited, Cyprus Amax Minerals Company, INCO Ltd., North Ltd., Phelps Dodge Exploration Corporation, Placer Dome Exploration Inc., Rio Tinto Mining and Exploration Limited, Teck Corporation,** and **WMC International Limited**. The objectives of the current porphyry subproject are to:

- Convert the existing porphyry, porphyry-related skarn, and epithermal (bulk mineable) deposits database release to a new general-purpose mineral deposits database structure designed specifically for the World Minerals Project.

- Review, compile, and digitally enter appropriate index-level, scientific and economic data current to December 1999 into the converted database.

- Prepare textual and structural database documentation and a map illustrating world distribution of porphyry, porphyry-associated skarn, and epithermal (bulk mineable) deposits and occurrences by radiometric age to accompany the digital dataset.

The Geological Survey invites users of this database to provide further information, comments, or corrections to the data.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the scientific and technical support of numerous people and organizations.

- Database compilation between 1983 and 1994 was carried out on an intermittent, part-time basis by the following: Allan Galley, Andy Douma, Janet Carrière, Dave Garson, and Kika Ross. Dave Garson also converted the mainframe version of the database to Access v.2.0.
- Lesley Chorlton provided the geological backdrop for the Open File Map and technical advice.
- Tim West and Mario Methot carried out the Open File Map cartography.
- Gary Labelle supervised and helped implement map cartography production.
- The structure of the 1995-1998 version database was improved by a review by Robert Laramée.
- Antonio Rafer assisted with library searches and filing.
- Gunnar Juve of the Norwegian Geological Survey provided a digital copy of the locations for the Mineral Atlas of the World, Map Sheet no. 9: Europe and Neighbouring Countries.
- Dymitry Rundqvist provided a digital copy of his database which was used for locations of some deposits in the C.I.S.
- Martin de Witt provided a copy of his database on mineral deposits and occurrences in the southern hemisphere.
- Keith Long provided a prepublication copy of the USGS Mineral Resource Database System which was used for the location of some deposits.
- F. Camus kindly provided production, reserve and resource data for CODELCO's important porphyry copper deposits in Chile.
- This manuscript was reviewed critically by W.D. Sinclair.

PART 1

DESCRIPTION OF THE DATABASE

1.1 DATABASE CONTENT

This database is deposit and ore zone based. Follows is a list of the data field descriptions for each deposit and, if applicable, its contained ore zones, grouped under five broad classification headings:

GENERAL AND LOCATION DATA

- unique reference number
- deposit reference number
- map number
- name
- alternate name(s)
- zone name
- country
- province/state
- county/quadrangle
- mineral district
- latitude/longitude (degrees, minutes, seconds and decimal degrees)
- location comment

GEOLOGIC DATA

- morphologic and genetic type
- morphologic and genetic subtype
- metal type
- petrochemical affinity
- tectonic setting
- degree of certainty (of geologic data)
- remarks
- reference number (maximum of 3)
- compilation/data entry/ data update names & dates

RESERVE/PRODUCTION DATA

- year of reserve-production summary-global production and reserve
- order number (see section 1.3.3.6)
- type of figure (reserve, production, combined production and reserve)
- production start year/month
- production end year/month
- metric tonnes
- short tons
- %Cu, %Mo, %Sn, %W, %Pb, %Zn
- other metal/grade (one other only allowed)
- g/t Au, oz/t Au
- g/t Ag, oz/t Ag
- comments
- reference number
- reference source (primary or secondary)
- compilation/data entry names & dates

RADIOMETRIC AGE DATA

- order number (see section 1.3.4.2)
- method
- mineral/concentrate dated
- published age
- accuracy (+ and - error, 2 sigma if known)
- revised age (incomplete, K-Ar only)
- age period (incomplete)
- what dated (ore mineral, alteration mineral, host rock etc.)
- comment
- reference number
- reference source (primary or secondary)
- compilation name & date
- best estimate of deposit age
- best estimate compiler & date

REFERENCE DATA

- reference number
- author(s)
- year
- title
- rest = remaining citation (includes editors, publication, publisher, country, volume, number, page (s))

Note that not all deposits have data available for each field.

The data are arranged in 4 tables (see Figure 1 for table relationships):

- PORPHDEP (general, location and geologic data)
- PORPHRP (reserve/production data)
- RADAGE (radiometric age data)
- REFERENCE (reference data)

Table ZONEREF is a junction table that ranks references in table PORPHDEP.

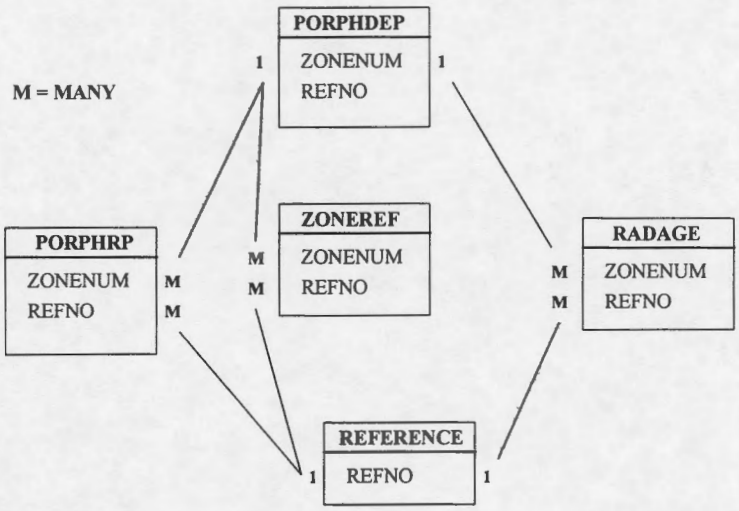

Figure 1: Relationship diagram

1.2 DATABASE DEFINITIONS

1.2.1 DEPOSIT AND ORE ZONE

For data compilation purposes, a **deposit** is considered the sum of known hypogene, supergene, and oxidized ore **zones**. Hypogene ore zones are considered primary mineralization spatially and genetically related to the deposit. Supergene enrichment of hypogene ore zones by weathering of primary sulphide minerals is considered secondary and typically increases copper grades in supergene sulphide ore zones. Oxidization of deposits can reduce sulphide contents of primary ore zones, thus improving extraction of gold by heap-leach methods. Oxide or "leach" ore is also considered secondary mineralization.

In many cases porphyry deposits are mined as a single operation and therefore all known ore zones can be established easily. At some localities, multiple operations mine faulted or politically separated segments (ore zones) of the same deposit (e.g. 1: Los Bronces - Rio Blanco, Chile, e.g. 2. El Pachon, Argentina - Los Pelambres, Chile). In these cases, it is difficult to establish the complete deposit picture. Some deposits, historically published as individual deposits, are now interpreted as ore zones within larger deposits (e.g. Miami-Inspiration-Bluebird-Van Dyke, United States). These recent interpretations are considered in the compilation of this database.

The ore zone is the primary unit that the data records. Where possible, general information, geological data, location, reserve/production data, and radiometric age are listed for individual ore zones. Deposit-scale information comprises one or more ore zones. If a deposit has only one ore zone, data were captured for that zone under the deposit name.

1.2.2 MORPHOLOGIC AND GENETIC DEPOSIT TYPES AND SUBTYPES

The morphologic and genetic characteristics of deposit types and subtypes in this database are as follows:

1.2.2.1 Porphyry type

Porphyry deposits are large, low- to medium-grade deposits in which hypogene ore minerals are primarily structurally controlled and which are spatially and genetically related to felsic to intermediate porphyritic intrusions (Kirkham, 1972). The large size and structural control (e.g. veins, vein sets, stockworks, fractures, 'crackled zones', and breccia pipes) serve to separate porphyry deposits from genetically-related (e.g. some skarns, high-temperature mantos, breccia pipes, peripheral mesothermal ("intermediate", "transitional") veins, epithermal precious-metal deposits), and unrelated deposit types (Kirkham and Sinclair, 1996).

1.2.2.1.1 Breccia subtype

The following two types of breccia pipes are considered porphyry subtypes:

- large tonnage breccia pipes (e.g. Rio Blanco - Los Bronces, Chile and Tribag East Breccia, Canada)
- small breccia pipes that are parts of porphyry deposits (e.g. Boss Mountain, Canada and Cananea, Mexico)

In some cases the distinction between porphyry-associated breccia deposits or breccia-associated porphyry deposits is difficult. Therefore, where possible, for clarification, description of the deposit is given in the comment field (REMARKS in PORPHDEP table).

1.2.2.1.2 Exotic subtype

Exotic copper deposits (e.g. Mina Sur (Exotica), Chile and Damiana, Chile) are considered porphyry subtypes since they form from supergene solutions which move laterally down shallow hydraulic gradients away from porphyry copper deposits undergoing supergene oxidation and enrichment (Sillitoe, 1995).

1.2.2.1.3 Vein/Replacement subtype

Peripheral mesothermal ("intermediate", "transitional") veins and replacement deposits are considered porphyry subtypes (e.g. Butte main stage veins, United States; Morococha, Peru; and Alwin, Canada)

1.2.2.2 Porphyry-Associated Skarn type

Porphyry-associated skarn deposits are defined here as skarn deposits with less than 50% non-calcsilicate stockwork genetically related to porphyry deposits (e.g. Needle Mountain zone of Gaspé deposit, Canada, Ingerbelle zone of Copper Mountain deposit, Canada)

1.2.2.3 Epithermal (Bulk Mineable) type

Epithermal (Bulk Mineable) deposits are bulk-tonnage epithermal precious metal (+/- base metals) deposits with abundant veins and/or stockworks associated with porphyry deposits (e.g. Ladolam, Papua New Guinea).

1.2.3 OPEN FILE MAP MORPHOLOGIC AND GENETIC SUBDIVISIONS

This database differentiates between genetically-related porphyry deposit types at two levels for the purposes of the map (Table 1, Appendix 5). Porphyry-associated skarn deposits and epithermal (bulk mineable) deposits are accorded the same level as porphyry deposits. These main level deposits are differentiated by distinct symbols on the map. Breccia pipes, exotic copper deposits, and peripheral vein/replacement deposits are considered a morphologic and genetic subdivision of porphyry deposits. These three subtypes are not distinguished on the map.

Table 1. Morphologic and genetic subdivisions

MAIN LEVEL	SUBTYPE LEVEL
Porphyry	Breccia
	Exotic
	Vein/Replacement
Porphyry-associated skarn	
Epithermal (bulk mineable)	

1.2.4 METAL TYPE

This database defines ten metal types for porphyry deposits (Table 2). Definition of types is based on the principle that metals essential to the economics of the deposit define the type; byproduct and potential byproduct metals are listed in parentheses (Kirkham and Sinclair, 1996).

Table 2. Metal-types for porphyry deposits (from Kirkham and Sinclair, 1996)

Metal Type	Metals (dominant metal(s) in bold type)
Cu-Au	**Cu-Au** + /-Ag
Cu	**Cu** + /-Au-Mo-Ag-Re
Au	**Au** + /-Ag-Cu-Mo
Cu-Mo	**Cu-Mo** + /-Au-Ag
W-Mo	**W-Mo** + /-Bi-Sn
W	**W** + /- Sn
Mo	**Mo** + /-W-Sn
Sn-Ag	**Sn-Ag** + /-W-Cu-Zn-Mo-Bi
Sn	**Sn** + /-W-Mo-Ag-Bi-In
Ag	**Ag** + /-Au-Zn-Pb

1.3 CLASSIFICATION AND FIELD DESCRIPTIONS

Below are descriptions of the five broad classification headings outlined in Section 1.1. Descriptions of some of the less explanatory data fields are listed as subheadings.

1.3.1 GENERAL AND LOCATION INFORMATION

This database aims to capture global data on significant porphyry deposits (see below) and some genetically-related skarn, breccia pipe, peripheral mesothermal ("intermediate", "transitional") vein and/or replacement, epithermal "bulk mineable", and other deposits. The database coverage of

porphyry-associated deposits is intended to complement data on porphyry deposits and is therefore not complete.

In some areas, such as the Cordillera of North and South America, where the density of known porphyry deposits is high, coverage of porphyry deposits is limited to those with production and/or reserve data or those with published radiometric age data or geological descriptions within known porphyry camps or districts. In areas where few or no porphyry deposits are known such as the Canadian Shield and parts of Asia, porphyry occurrences with minor or unknown reserves and limited published documentation are included in the database.

Deposits are recorded with current name, alternate name(s), and individual zone names. Where possible, the following political parameters are recorded in the database: country, province/state, quadrangle/county, mining district.

All deposits have a longitude and latitude reading. Where possible locations for individual ore zones within the deposits are also given. The readings were compiled directly from reported coordinates and the source (author/year) for the coordinates is given in the location comment field. Alternatively, readings were indirectly measured from reference maps or calculated from written information on the distance from a town/deposit. The accuracy of indirect measurements is qualitatively described in the location comment field ENTCOM (e.g. location approximate, location to nearest degree only).

1.3.2 GEOLOGICAL INFORMATION

Geological information is collected systematically in fields and non-systematically as remarks in table PORPHDEP. The following parameters are collected systematically:

- Petrochemical Affinity see Table 14
- Tectonic Setting see Table 15

The following parameters are described non-systematically as remarks in either field REMARKS of table PORPHDEP or field AGECOMM of table RADAGE:

- Host rock formation
- Host rock composition
- Host intrusion composition
- Sulphide mineralogy
- Silicate, carbonate, oxide mineralogy
- Mineralization character
- Alteration type

1.3.2.1 Field: PETRO

Intrusions related to porphyry deposits show a wide range in compositions and petrogenetic associations (Kirkham and Sinclair, 1996). This database records petrochemical affinities of host intrusions using a predefined pick list (Table 14) if published information is available.

1.3.2.2 Field: TECTSET

The tectonic setting of deposits, especially those in ancient terranes, is difficult to determine and often hotly debated. However, tectonic features of deposits can be helpful in understanding the distribution and complexity of deposits. This database records inferred island arc, back arc, continental arc, arc-type unknown, collision zone, rift-related, other or unknown tectonic settings (Table 15) where published information is available or can be inferred from close proximity to other

deposits in known tectonic settings. Deposits described as continental margin type are grouped with continental arc deposits in this database.

1.3.3 RESERVE AND PRODUCTION INFORMATION

This database is intended to record published reserve and production figures to December 1997. Some old reserve figures are also retained for historical value; these may be preproduction or have grades for metals that are not currently reported.

1.3.3.1 Field: RP

Reserve/Production (R/P) data are defined (Table 19) as:

- Reserve
- Production
- Published Reserve and Production
- Calculated Reserve and Production

1.3.3.2 Field: YEAR-SUMMARY-GLOBAL

The field YEAR-SUM-GLOBAL indicates:

- YEAR (year of published reserve or production figure)
- S (for summary if Production is a summary for more than one year)
- G (for global if the figure is a published or calculated productionand reserve figure - see section 2.5.3.).

1.3.3.3 Fields: STYR, ENDYR, STMO, ENDMO

Start and end year/month fields indicate years of production.

1.3.3.4 Fields: TONNES, STONS, CU, MO, AU, MAU, AG, MAG, SN, W

Tonnage is listed both as metric tonnes and short tons. Tonnage conversion was calculated automatically using the method described in Section 2.5.1. Cu, Mo, Au, Ag, Sn, and W grades are systematically recorded for each R/P figure; other metals are recorded non-systematically (Table 5). The database automatically calculates the grade conversion for Au and Ag (see Section 2.5.1).

1.3.3.5 Field: RPCOMMS

R/P data qualifiers are given in the RPCOMMS field of the PORPHRP table. Examples of Reserve qualifiers are in Table 3.

Table 3. Reserve and production data qualifiers in RPCOMMS field of table PORPHRP.

Ore Type	Type of Reserve	Type of Production	Other Qualifier
Sulphide	"Estimated" Reserve	Open Pit	% or g/t Cutoff
Oxide	Mineral Inventory	Underground	Strip Ratio
Hypogene	Resource	Block Caving	no qualifier given
Supergene	Geological Resource	Past Production	Status
Leach	Total Resource	"Estimated" Production	Recovered grade
Mill	Inferred Resource/Reserve	Cathode copper (or Cu)	
Stockpile	Implied Resource/Reserve	Daily	
"Dump"	Mineable Reserve	Tonnes per day (TPD)	
"Waste"	Open Pit Reserve/Resource	Tonnes per year (TPY)	

Ore Type	Type of Reserve	Type of Production	Other Qualifier
"Tailings"	Underground Reserve/Resource		
"In-situ"	Proven Reserve		
Concentrate	Probable Reserve		
	Possible Reserve		
	Drill-Indicated Reserve		
	Preliminary Reserve		
	Preproduction (or Pre-Mining) Reserve/Resource		

1.3.3.6 Field: RPNUM

Each reserve or production record (ore zone scale) has an order number given in the field RPNUM. This number allows the data to be sorted and/or printed from highest to lowest priority as follows:

- published production and reserve
- calculated production and reserve
- production
  - most complete summary
  - oldest recorded production (years)
  - youngest recorded production (years)
- proven reserve
- probable reserve
- possible reserve
- total resource
- inferred resource
- implied resource
- resource
- dumps
- tailings/waste.

1.3.4 AGE INFORMATION

The database contains a comprehensive collection of radiometric ages from porphyry mineralization, host intrusions, and related igneous rocks. Most porphyry deposits are Triassic or younger, but individual deposits range in age from approximately 3.0 Ga to Recent (Kirkham and Sinclair, 1996).

Radiometric ages and accuracy of ages are recorded using the methods and minerals listed in Tables 21 and 22. Revised ages were calculated using the constants recommended by Steiger and Jäger (1977) for K-Ar dates which were published, typically pre-1978, using other decay constants. Expanded information on the radiometric ages is non-systematically recorded in the AGECOMM field of table RADAGE. Where possible an explanation of the date with some of the following information is recorded for each record:

- formal name of the igneous rock
- rock type (e.g. diorite)
- relationship of intrusion/volcanic rock to mineralization (pre-mineral, inter-mineral, post-mineral)
- alteration/mineralization type
- if reported date is averaged from a number of samples, number of analyses averaged stated as N = number
- sample number or unit number from data source

1.3.4.1 Field: WHAT DATED?

The object dated by radiometric dating techniques is qualified by compilers using information available in published references. Descriptions of the object dated are selected from the lookup table xwhatdated (Table 23).

1.3.4.2 Field: AGENUM

Each radiometric age record (ore zone scale) has an order number given in the field AGENUM. This number allows the data to be sorted and/or printed from highest to lowest priority as follows:

- deposit age (hypogene ore/alteration)
- host intrusion age
- host volcanic rocks
- pre/post-mineral intrusion
- pre/post-mineral volcanic rocks
- supergene ore/alteration age

1.3.4.3 Field: BEST AGE EST

A best age estimate for the deposit age has been selected at the deposit scale for deposits with published radiometric age information. The priority sequence for choosing the date is as follows:

- best age estimate in recent geological reference
- age of hypogene mineralization
- age of potassic alteration associated with mineralization
- age of phyllic/sericitic alteration associated with mineralization
- age of host intrusion

1.3.5 REFERENCES

The database records general geological, reserve/production, and radiometric age references in the table REFERENCE (Table 8). Each record in this table has a unique reference number that is used to link the reference to the appropriate data in other tables. Deposits or ore zones must have at least one reference; there is a reference limit of 3 for general geological references and no reference limit for reserve/production, and radiometric age references.

Publications in this database include:

- refereed and non-refereed journals
- government publications
- geological society and association publications
- conference proceedings
- fieldtrip guidebooks
- university theses
- personal communication
- mining industry magazines
- mining industry newspapers
- other compilations

1.3.5.1 Field: REFERENCE SOURCE

The database distinguishes primary from secondary sources of compiled information in several ways by:

- using a source field (Table 22)

- directly adding the author(s) and year of the original reference in the comment fields of the tables PORPHRP and RADAGE

Note that primary references listed as "data from" in the comment fields are not listed in the table REFERENCE since they cannot be directly linked to record data.

1.4 DATA QUALIFIERS/RELIABILITY

1.4.1 LOCATION

Locations of deposits are taken from primary document sources where possible. Where document sources are secondary, taken from other compilations (eg. USGS MRDS, CGMW maps) or where locations have been calculated by data compilers, qualifiers for the location data are given in the ENTCOM field of the PORPHDEP table.

1.4.2 GEOLOGICAL AND DEPOSIT CLASSIFICATION DATA

Since data have been compiled from various referenced sources, both primary and secondary, a subjective rating system for the certainty and reliability of deposit data has been created in the field DEGREE OF CERTAINTY of table PORPHDEP. This rating system (Table 13) is applied to deposits added since 1995.

1.4.3 REFERENCES

Data are compiled where possible from primary reference sources. In some cases, the original source is not used as a reference either because the information was a personal communication and never published or because the quoted reference source has not been reviewed by compilers to date (perhaps not in English or obscure source).

Reference sources are distinguished using the field REFERENCE SOURCE (Section 1.3.5.1). Use of this field allows database users to assess reliability of compiled data.

1.5 REPORT REFERENCES

Kirkham, R.V.
1972: Porphyry deposits; in Report of Activities, Part B: November 1971 to March 1972; Geological Survey of Canada, Paper 72-1, Part B, p. 62-64.

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1996: Porphyry copper, gold, molybdenum, tungsten, tin, silver; in Geology of Canadian Mineral Deposit Types (ed.) O.R. Eckstrand, W.D. Sinclair, and R.I. Thorpe; Geological Survey of Canada, Geology of Canada, no. 8, p. 421-446.

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PART 2

DATABASE DESIGN

2.1 CURRENT SIZE OF THE DATABASE

The database is current to January 1998 and contains information on 783 deposits and occurrences comprising 1022 ore zones in 62 countries. There are 1572 individual production and reserve figures on 508 deposits, and 886 radiometric age determinations on 339 deposits. A comprehensive reference list of 1320 references is linked to the database.

2.2 LIMITATIONS OF DATABASE

This database is "index-level". Contained information was selected to yield useful information at a global scale. The parameters below are not considered to yield index-level information at the present development stage of the database.

1. systematic collection of the following parameters in table PORPHDEP (see section 1.3.2)
   - Host rock formation
   - Host rock composition
   - Host intrusion composition
   - Sulphide mineralogy
   - Silicate, carbonate, oxide mineralogy
   - Mineralization character
   - Alteration type
2. systematic collection of the following parameters in table PORPHRP (see section 1.3.3.5)
   - Ore type
   - Type of reserve
   - Type of production
   - Cutoff grade

2.3 DATABASE STRUCTURE

2.3.1 UNIQUE REFERENCE KEY

In this database, deposits are given a 6-digit numerical identifier field called LINKORZ in table PORPHDEP. The first 4 digits of the number refer to the deposit (e.g. 1355) and the last 2 digits are always 00. Ore zones are given also given a 6-digit numerical identifier field called ZONENUM in table PORPHDEP, PORPHRP, and RADAGE. The first 4 numbers of the number are the same as the deposit identifier (e.g. 1355) but the last 2 numbers are unique and refer to the ore zone number for the deposit (e.g. 01). This field is the unique reference key for the database: records in all the tables are linked by this number.

2.3.2 DATABASE TABLES

The database has a "daisy" structure comprising three tables describing a single object (the ore zone). The three tables, PORPHDEP, PORPHRP, and RADAGE are linked by 1 to many relationships from the table PORPHDEP (Figure 1 - relationship diagram). A fourth table called REFERENCES is linked by 1 to many relationships to tables PORPHRP, RADAGE, and ZONEREF (a junction table that ranks references in table PORPHDEP):

- PORPHDEP general and geological information; up to 3 general references
- PORPHRP reserve and production information; 1 reference per record
- RADAGE radiometric age information on related intrusions/host rocks and mineralization, 1 reference per record
- REFERENCE reference information; 1 reference per record
- ZONEREF junction table; ranks the 3 general references in table PORPHDEP

Field names, properties and descriptions for each table are in Tables 4 to 8.

Table 4. Field names, properties, and descriptions for the table PORPHDEP

NAME	FIELD TYPE	FIELD SIZE (bytes)	DESCRIPTION
LINKORZ	Number	4	Link number for deposit (first 4 digits)
ZONENUM	Number	4	Unique reference key link number for deposit (first 4 digits as LINKORZ) and ore zone (last 2 digits)
MAP NUMBER	Number	2	Assigned number used on Open File map (by country; read from North to South and West to East)
COUNTRY	Text	20	Country (see lookup table xCOUNTRY)
NAME	Text	50	Deposit name
ZONENAME	Text	50	Ore zone name
ALTNAME	Text	40	Alternative deposit name(s)
ENTCOM	Text	70	Comment on location of deposit (source of location data, distance from nearest town, relationship to other deposits in camp/centre)
GEOSUB1	Text	21	Geographic subdivision (level 1) - province/state
GEOSUB2	Text	30	Geographic subdivision (level 2) - county/quadrangle
MINDIST	Text	30	Mining district (if known)
LATD	Number	1	Degrees of latitude
LATM	Number	1	Minutes of latitude
LATS	Number	1	Seconds of latitude
LATNS	Text	1	N for north latitude, S for south latitude
LATDECIMAL	Number	8	Decimal degrees of latitude
LONGD	Number	1	Degrees of longitude
LONGM	Number	1	Minutes of longitude
LONGS	Number	1	Seconds of longitude
LONGEW	Text	1	E for east longitude, W for west longitude
LONGDECIMAL	Number	8	Decimal degrees of longitude
REMARKS	Text	220	Remarks on deposit (host rocks, intrusions, etc.)
CODEDBY	Text	20	Coded by, last name + initials (see lookup table xBY)
CODEDYR	Number	2	Coded in year (see lookup table xYEAR)
CODEDMO	Number	1	Coded in month (see lookup table xMONTH)

NAME	FIELD TYPE	FIELD SIZE (bytes)	DESCRIPTION
UPDTBY	Text	20	Updated by, last name + initials (see lookup table xBY)
UPDTYR	Number	2	Updated in year (see lookup table xYEAR)
UPDTMO	Number	1	Updated in month (see lookup table xMONTH)
MORPH	Text	50	Deposit morphologic and genetic type (see lookup table xMORPH)
MORPH-SUBTYPE	Text	20	Morphologic and genetic subtype (see lookup table xMORPH-SUB)
METALTYP	Text	5	Metal association (see lookup table xMETAL TYPE)
PETRO	Text	50	Petrogenetic type (see lookup table xPETROCHEMICAL AFFINITY)
TECTSET	Text	30	Tectonic setting (see lookup table xTECTSET)
DEGREE CERTAINTY	Text	10	Degree of certainty of morphology and metal type
REFNO	Number	4	Primary geological reference for deposit (by reference number). To look up reference see table REFERENCE
REFNO2	Number	4	Secondary geological reference for deposit (by reference number). To look up reference see table REFERENCE
REFNO3	Number	4	Tertiary geological reference for deposit (by reference number). To look up reference see table REFERENCE
BEST AGE EST	Number	4	Best estimate of deposit age selected from ages in table RADAGE
GLOBAL CU (MT)	Number	4	Best calculated global Cu resource estimate from data in table PORPHRP
GLOBAL MO (MT)	Number	4	Best calculated global Mo resource estimate from data in table PORPHRP
GLOBAL AU (T)	Number	4	Best calculated global Au resource estimate from data in table PORPHRP
GLOBAL AG (T)	Number	4	Best calculated global Ag resource estimate from data in table PORPHRP
GLOBAL SN (MT)	Number	4	Best calculated global Sn resource estimate from data in table PORPHRP
GLOBAL W (MT)	Number	4	Best calculated global W resource estimate from data in table PORPHRP

Table 5. Field names, properties, and descriptions for the table PORPHRP

NAME	FIELD TYPE	FIELD SIZE (bytes)	DESCRIPTION
ID	Number	4	Identity number
ZONENUM	Number	4	Link# and Orezone# (last 2 digits)
RPNUM	Text	2	Order number for reserve and production data on a deposit scale (see section 1.3.3.6)
RP	Text	35	Reserve, production, calculated production and reserve, published production and reserve
YEAR-SUMMARY -GLOBAL	Text	4	4 digit number = year of reserve, S = summary of production years (years given if available in STYR and ENDYR), G = global
STYR	Number	2	Start year of production
STMO	Number	1	Start month of production
ENDYR	Number	2	End year of production period
ENDMO	Number	1	End month of production period
TONNES	Number	8	Metric tonnes of ore
STONS	Number	8	Short tons of ore
CU	Number	8	Cu grade in %
MO	Number	4	Mo grade in %
PB	Number	4	Pb grade in %
ZN	Number	4	Zn grade in %
MAU	Number	8	Au in g/t
AU	Number	8	Au in troy oz/t
MAG	Number	8	Ag in g/t
AG	Number	8	Ag in troy oz/t
SN	Number	4	Sn grade in %
W	Number	4	W grade in %
METAL1	Text	2	Other metal
GRADE1	Text	8	Grade of other metal in %
RPCOMMS	Text	100	Comments on reserve/production figures
REFNO	Number	4	Reference for reserve/production data (by reference number). To look up reference see table REFERENCE
REFERENCE SOURCE	Text	9	Primary or secondary (see lookup table xREFERENCE SOURCE)
RPCODEDBY	Text	20	Coded by (see lookup table xBY)
RPCODEDYR	Number	2	Coded in year (see lookup table xYEAR)
RPCODEDMO	Number	1	Coded in month (see lookup table xMONTH)
MODBY	Text	20	Modified by (see lookup table xBY)
MODYR	Number	2	Modified year (see lookup table xYEAR)
MODMO	Number	1	Modified month (see lookup table xMONTH)

Table 6. Field names, properties, and descriptions for the table RADAGE

NAME	FIELD TYPE	FIELD SIZE (bytes)	DESCRIPTION
IDEN	Number	4	Identity number
ZONENUM	Number	4	Link# and Orezone# (last 2 digits)
AGENUM	Number	8	Order number for age data on an ore zone scale (see section 1.3.4.2)
RAGE	Number	8	Radiometric age
CONSTANTS	Text	1	If K-Ar method, constants of Steiger and Jäeger (1977) used, Y = yes, N = no
RAGEPERIOD	Text	50	Age period
RAGEREV	Number	8	Revised radiometric age (new constants)
+ ERROR	Text	5	+ error for RAGE
- ERROR	Text	5	- error for RAGE
2 SIGMA MARGINS?	Text	1	2 sigma margins used for error calculations for RAGE? Y=yes, N = no
AGEMETH	Text	13	Age method
AGEMIN	Text	27	Mineral/concentrate used for dating
AGECOMM	Text	200	Comments on age figures (including rocktype)
WHAT DATED?	Text	50	Value list in lookup table xWHATDATED (ore mineral, alteration mineral, host intrusion etc.)
REFERENCE SOURCE	Text	9	Primary or secondary (see lookup table xREFERENCE SOURCE)
REFNO	Number	4	Reference for age data (by reference number). To look up reference see table REFERENCE
GCODEDBY	Text	20	Coded by (see lookup table xBY)
GCODEDYR	Number	2	Coded year (see lookup table xYEAR)
GCODEDMO	Number	1	Coded month (see lookup table xMONTH)
AGEBESTEST	Number	8	Best age estimate for deposit
AGEBESTACCUR	Text	5	Accuracy of best age estimate
BCODEDBY	Text	20	Best age coded by (see lookup table xBY)
BCODEDYR	Number	2	Best age coded year (see lookup table xYEAR)
BCODEDMO	Number	1	Best age coded month (see lookup table xMONTH)

2.3.3 REFERENCE TABLE

Each record in the 3 tables PORPHDEP, PORPHRP and RADAGE has a reference. Records in table PORPHDEP can have up to 3 general references. Table ZONEREF is used to distinguish between ranked references in table PORPHDEP (Table 7). The references are linked by 1 to many relationships using a unique 4-digit numerical field called REFNO to an additional stand alone table REFERENCE (Figure 1). Field names, properties and descriptions for the reference table are in Table 8.

An example of the number of potential number of references linked to a deposit:

-deposit with 3 ore zones
-each ore zone has 3 reserve and production figures
-deposit has 2 radiometric age figures
therefore deposit could have up to 20 different references.

Table 7. Field names, properties, and descriptions for the table ZONEREF

NAME	FIELD TYPE	FIELD SIZE (bytes)	DESCRIPTION
ZONENUM	Number	4	Ore zone number (unique reference key)
REFNO	Number	4	Reference identity number (unique reference key)
RANK	Number	4	Order of importance of references in table PORPHDEP

Table 8. Field names, properties, and descriptions for the table REFERENCE

NAME	FIELD TYPE	FIELD SIZE (bytes)	DESCRIPTION
REFNO	Number	4	Reference identity number (unique reference key)
AUTHORS	Text	255	Authors
PUB_YEAR	Text	255	Year of publication
TITLE	Text	254	Title of publication
REST	Text	255	Remaining citation (includes editors, publication, publisher, country, volume, number, page (s))

2.3.4 LOOKUP TABLES

The database has a number of closed lists of values stored in 15 lookup tables. These tables were used for data entry to ensure consistency of data (Tables 9 to 23).

Table 9. Country name lookup table (xCNTRIES)

COUNTRY					
ARGENTINA	CUBA	GUYANA	MALAYSIA	PUERTO RICO	THAILAND
ARMENIA	CZECH	HAITI	MEXICO	ROMANIA	TURKEY
AUSTRALIA	DOMINICAN REPUBLIC	HONDURAS	MONGOLIA	RUSSIA	UKRAINE
BELIZE	ECUADOR	HUNGARY	MYANMAR	SAUDI ARABIA	UNITED KINGDOM
BOLIVIA	ERITREA	INDIA	NAMIBIA	SERBIA	UNITED STATES
BRAZIL	ETHIOPIA	INDONESIA	NEW ZEALAND	SLOVAKIA	URAGUAY
BURKINA FASO	FIJI	IRAN	NICARAGUA	SOLOMON ISLANDS	UZBEKISTAN
BULGARIA	FINLAND	IRELAND	NIGER	SOUTH AFRICA	VENEZUELA
CANADA	FRENCH GUIANA	ITALY	NORWAY	SOUTH KOREA	VIETNAM
CHILE	GEORGIA	IVORY COAST	PAKISTAN	SPAIN	YUGOSLAVIA
CHINA	GERMANY	JAPAN	PANAMA	SURINAME	
COLOMBIA	GREECE	KAZAKHSTAN	PAPUA NEW GUINEA	SWEDEN	
COSTA RICA	GREENLAND	KYRGHYZSTAN	PERU	TAIWAN	
CROATIA	GUATEMALA	MACEDONIA	PHILIPPINES	TAJIKISTAN	

Table 10. Deposit morphology and genetic type lookup table (xMORPHOLOGIC and GENETIC TYPE)

MORPHOLOGY			
PORPHYRY	PORPHYRY-ASSOCIATED SKARN	EPITHERMAL (BULK MINEABLE)	OTHER OR UNKNOWN

Table 11. Deposit morphology subtype lookup table (xMORPH-SUBTYPE)

MORPH-SUBTYPE			
BRECCIA	EXOTIC	VEIN/REPLACEMENT	OTHER

Table 12. Metal-type lookup table (xMETAL-TYPE)

METAL-TYPE									
CU	CU-MO	CU-AU	AU	MO	W-MO	SN	SN-AG	AG	OTHER

Table 13. Degree of certainty (of deposit morphology) lookup table (xDEGREE OF CERTAINTY)

DEGREE OF CERTAINTY				
VERY HIGH	HIGH	MODERATE	LOW	VERY LOW

Table 14. Petrochemical affinity lookup table (xPETROCHEMICAL AFFINITY)

PETROCHEMICAL AFFINITY				
ALKALIC	CALC-ALKALIC	F -& ALKALI-RICH, HIGH-SILICA GRANITE (RHYOLITE)	TONALITIC (LOW K THOLEIITIC)	OTHER

Table 15. Tectonic setting lookup table (xTECTSET)

TECTONIC SETTING						
ISLAND ARC	BACK ARC	ARC - TYPE UNKNOWN	COLLISION ZONE	CONTINENTAL ARC	RIFT	UNKNOWN OR OTHER

Table 16. Compiler lookup table (xBY)

BY				
DOUMA, A.G.	DUNNE, K.P.	GARSON, D.F.	KIRKHAM, R.V.	ROSS, K.V.

Table 17. Year of compilation lookup table (xYEAR)

YEAR												
1982	1983	1984	1985	1986	1990	1991	1994	1995	1996	1997	1998	1999

Table 18. Month of compilation lookup table (xMONTH)

MONTH											
1	2	3	4	5	6	7	8	9	10	11	12

Table 19. Type of published figure lookup table (xRP)

RP			
RESERVE	PRODUCTION	PUBLISHED PRODUCTION AND RESERVE	CALCULATED PRODUCTION AND RESERVE

Table 20. Age method lookup table (xMETHOD)

AGE METHOD						
AR-AR	FISSION TRACK	K-AR	U-PB	PB-PB	RB-SR	OTHER

Table 21. Age mineral/concentrate lookup table (xAGE MINERAL)

AGE MINERAL					
ADULARIA	BIOTITE	ILLITE	ORTHOCLASE	SERICITE	WHOLE ROCK
ALUNITE	FELDSPAR	K-FELDSPAR	OTHER	TITAN-FELDS	ZIRCON
AMPHIBOLE	GALENA	MONAZITE	PLAGIOCLASE	TITANITE	
APATITE	HORNBLENDE	MUSCOVITE	SANIDINE	UNKNOWN	

Table 22. Reference Source Lookup Table (xREFERENCE SOURCE)

REFERENCE SOURCE	
PRIMARY	SECONDARY

Table 23. What Dated Lookup Table (xWHATDATED)

WHAT DATED		
ORE - HYPOGENE	INTRUSION - PRE-MINERAL	ALTERATION - SUPERGENE
ALTERATION - HYPOGENE	INTRUSION - POST-MINERAL	VOLCANIC - PRE-MINERAL
INTRUSION - HOST	INTRUSION - OTHER	VOLCANIC - POST-MINERAL
VOLCANIC - HOST	OTHER/UNSPECIFIED	ORE - SUPERGENE

2.4 CALCULATIONS

This database performed a number of automatic calculations to assist data entry procedures and provide global contained metal information on deposits.

2.4.1 TONNAGE AND GRADE CONVERSION

Tonnage and Au, Ag grade conversion from metric to imperial and vice versa were performed automatically on data entry using a form. These calculations were achieved by calling on an Access v.7.0 event procedure (macro) after form update.

Limitations of this procedure are the presence of additional significant figures for calculated tonnage and grade data.

2.4.2 DECIMAL DEGREE CONVERSION

Latitude and longitude conversion from degrees, minutes and seconds with direction identifiers (N, S, E, W) to decimal degrees (positive northing and easting, negative southing and westing) were performed automatically using an Access v.7.0 event procedure (macro). The event procedure placed results in fields LATDECIMAL and LONGDECIMAL of table PORPHDEP.

2.4.3 GLOBAL CONTAINED METAL

The database records global (or deposit total) contained metal content of Cu, Mo, Au, Ag, Sn and W in table PORPHDEP. This figure, calculated on a deposit scale, is the published or manually calculated sum of contained metals in all known economic hypogene, supergene and oxidized ore zones, dumps and stockpiles. Recently published global contained metal contents of deposits are recorded in table PORPHRP as records with the field RP = PUBLISHED PRODUCTION + RESERVE and with the field YEAR-SUMMARY-GLOBAL = G (for global). For unpublished global figures, sums of contained metals for all recorded ore zones, dumps and stockpiles were calculated manually by compilers and recorded in table PORPHRP as field RP = CALCULATED PRODUCTION + RESERVE and with the field YEAR-SUMMARY-GLOBAL = G (for global).

Global contained metal is reported in the fields GLOBAL CU (MT), GLOBAL MO (MT), GLOBAL AU (T), GLOBAL AG (T), GLOBAL SN (MT), GLOBAL W (MT) of table PORPHDEP (Note that MT = millions of tonnes). These fields were used for generation of deposit size classification for the map that accompanies this database (Appendix 5).

2.5 ABBREVIATIONS

Some abbreviated words are used in fixed-length comment fields in order to include as much information as possible. This is a limitation of the early design of this database. Abbreviations for rock and mineral names and descriptive and structural terms are taken from the guidelines set out in:

Chace, F.M. 1956: Abbreviations in Field and Mine Geological Mapping, Economic Geology, v. 51, p. 712-723.

Follows is a list of other abbreviations used:

NM	Northern Miner newspaper	BT	Billion tonnes	T	Tonnes
R/P	Reserve/Production	TR	Troy	ST	Short tons
MT	Million tonnes	OZ	Ounces (Imperial)	~	Approximately