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FOREWORD: About this database by L.B. Chorlton

The substance of of this publication is the uranium, thorium, and rare earth element mineral occurrence database in full (Access® 2000format), as well as export products derived from this database. The purpose of this foreword is to provide a brief background and history of the database, plus information about the database schema itself and the tools created to support it.

Background to uranium exploration in Canada and the history of the database

Uranium became a commodity of strategic importance in the early half of World War II due to advances in research on atomic weapons, prior to which it held little value. The Eldorado silver-radium-copper-cobalt mine, located on the southeast shore of Great Bear Lake, Northwest territories, closed in 1940 due to failing markets. However, because it was recognized as the largest known source of uranium on the continent, the company was asked to re-open the mine in 1942 for uranium extraction (Lang, 1951). In 1944, Eldorado was acquired by the Crown and became Eldorado Mining and Refining Limited. The Crown asked the Geological Survey of Canada (GSC) to assist the company in finding new ore, and field parties were sent to Great Bear Lake and other prospective districts in Canada. After much surveying and prospecting by Eldorado and the GSC, the prolific Beaverlodge uranium district in northern Saskatchewan opened up for mining. Eldorado was contracted by the United States to supply military stockpiles.

Meanwhile in 1942, the Canadian Nuclear industry began under the administration of the National Research Council (NRC) (Wikipedia, 2015a). It involved the development of nuclear reactors for research purposes and for the production of radio-isotopes for medical uses. The Canadian Government formed Atomic Energy of Canada Limited (AECL) in 1952 to develop peaceful applications of nuclear energy, including power generation. The first nuclear plant became operational in 1962, successfully launching the nuclear power industry which further enhanced the strategic importance of uranium. Nuclear power generators were built in Ontario, Quebec, and New Brunswick, along with several other research reactors in diverse locations (Wikipedia, 2015b).

In 1946, the government of Canada passed the Atomic Energy Control Act (AECA) which established the Atomic Energy Control Board (AECB) to oversee all matters related to atomic energy, which included the natural occurrence, inventory, and uses of these materials (Lang, 1951). The AECB made use of staff of other government agencies, such as the National Research Council to investigate industrial uses of atomic energy. The Department of Mines and Technical Surveys, which included a Mines Branch that researched uranium concentration and extraction and the GSC that investigated the mineralogy and geology of radioactive occurrences, was also called upon. Prospectors and companies were compelled by the AECA to supply data to the GSC on the occurrences they had located, including production and resource data, for compilation into a confidential inventory to be submitted annually to the AECB. In 1947, having previously restricted prospecting for radioactive materials in the federal territories of Yukon and Northwest Territories, the Canadian government lifted the ban and encouraged private prospecting by guaranteeing a minimum price for uranium, a guarantee which was extended until 1960. Provincial governments that had likewise banned private prospecting lifted their own bans. Increased prospecting and government encouragement ultimately led to the development of new mines in uranium districts such as Bancroft and Blind River-Elliot Lake, Ontario. These mines thrived on contracts negotiated through Eldorado Mining and Refining with the United States Atomic Energy Commission until 1962, and with the United Kingdom Atomic Energy Agency for deliveries between 1963 and 1966. They also benefited under the Canadian Income Tax Act from three year tax exemptions, depletion allowances, and deductions for expenses (Proulx, 1997).

The GSC thus formed a Uranium Resource Assessment Group (URAG) to study uranium in the field and in the laboratory, and to produce the mandated confidential reports. To further encourage prospecting, the GSC published a paper describing the history of exploration for radium and then uranium, the mineralogy and other geological attributes of uranium deposits, characteristics of known deposits, and the regions of Canada with known potential for radioactive minerals (Lang, 1951). This was followed by two editions of the Economic Geology Series 16 containing, in addition to descriptive text, tabular listings of known radioactive occurrences with index level attributes (Lang, 1952; Lang et al., 1962). URAG supported the exploration industry by providing many publications related to their investigations throughout its nearly four decades of operation. The GSC provided additional strategic support for uranium exploration when it mounted the Federal-Provincial

Uranium Reconnaissance Program in 1974 (Darnley et al., 1975) in response to concerns about energy security in the wake of oil price rises due to an embargo by the Organization of Arab Petroleum Exporting Countries.

The capturing and organization of index level information for uranium occurrences reaped from company reports and government field work and research, was an essential by-product of the activities of URAG. It is highly likely that the occurrence listings in Lang (1951) and Lang et al., (1962) were maintained as card files. By the late 1960s the GSC was attempting to capture mineral occurrence information in digital databases, and by the late 1970s these databases partially preceded or co-existed with a general purpose index level multi-user mineral occurrence database called CANMINDEX (Picklyk et al., 1978). The listings of Lang et al. (1962), several precursor uranium databases targeting specialized deposit types, and the uranium-related contents of other card files such as the National Mineral Inventory of the Mineral Policy Sector of the time, were incorporated into a CANMINDEX-style database for uranium and thorium (Prasad, 1981). This database was updated intermittently for URAG into the mid-1990s, when uranium became less strategic, militarily following the end of the Cold War, and industrially because of the cooling of enthusiasm for nuclear energy due to safety concerns. The Nuclear Safety and Control Act, passed in 1997, replaced previous legislation and scrapped mandatory reporting for exploration companies. The services of the URAG were no longer required by law, and the group was disbanded during government down-sizing.

Other commodity specialists in the Economic Geology Section at the GSC had been compiling mineral deposit inventories for individual specialized projects, some of which (porphyry copper and molybdenum) were imported into CANMINDEX-style databases (Picklyk et al., 1978) or into specially designed project databases (Jenkins et al., 1997). These specialists studied the largest world class ore deposits in order to better understand Canadian examples, and thus the geographic scope of the data collected became global. The databases were commonly put to use for plots of deposit points on transparent mylars overlain on paper geology maps, and for tabular listings included in mineral deposit publications.

Meanwhile, Geographical Information Systems (GIS) came into common use, and digital cartography gradually replaced manual cartography for the production of geological maps. Government geoscientists as well as exploration companies wanted digital data for mineral deposits that could be integrated with geological and other maps using GIS software. R.V. Kirkham, in particular, was interested in plotting sediment-hosted copper deposits prepared from his CANMINDEX-style database over a digital world geology map in GIS format, for which the author of this Foreword was hired on contract. Although the original intention was to produce a paper map (Kirkham et al., 1994), this exercise ultimately resulted in the digital release of Open File 2915d, (Geological Survey of Canada, 1995) which contained two global deposit databases plus the world geology. Following OF 2915d, money was raised from private exploration companies to continue global deposit and geology compilations under the World Map Project (1996-1997), and subsequently under the World Minerals Geoscience Database Project (WMGDP: 1998-2004)[1]. Industry indicated which deposit types and commodities the WMGDP should compile, which included base metals and gold, but not uranium. A synopsis of the WMGDP database schema and tools development, GlobalDBSchema, is found below.

After end of the WMGDP, interest in uranium exploration in Canada revived. Several GSC projects, such as a study of the geology and uranium exploration technology of the Athabasca Basin under EXTECH IV (Jefferson et al., 2007), the study of several uranium districts across Canada under the program Secure Energy Supply, and the study of the Thelon Basin-Amer fold belt and Baker Lake area under Northern Resource Development and Geo-mapping for Energy and Minerals programs, rekindled the need to update the Canadian uranium database for targeted areas. As a result, the entire Canadian URAG database was imported into the WMGDP format. S.S. Gandhi was contracted to update deposits and occurrences in and around the Athabasca Basin, Saskatchewan (Gandhi, 2007), and subsequently to update deposit data for the Thelon Basin-Amer fold belt (Nunavut), the Central Metasedimentary Belt (Ontario), the Otish Basin area (Quebec), and the Central Mineral Belt (Labrador). N. Prasad updated data for many occurrences in Newfoundland. Caroline Richer, supervised by Dave Lentz, updated select deposits of the Grenville Province, Ontario and Quebec. Former WMGDP staff filled in as many gaps as possible elsewhere with reference to provincial databases and in response to breaking exploration news for deposits which were not contract priorities. Because several rare earth element (REE) deposits, being radioactive, had already been included in the URAG database, and because there have been several REE deposits in the news in recent years, the scope of the U-Th database was expanded to include major REE developments.

One of the challenges for compilation of all types of mineral deposits has been classification. Classification systems tend to evolve as more is known about key deposit types. The purpose of the classification is significant, and can vary from guiding regional exploration assumptions for target selection, to predicting tonnage and grade, to modelling for detailed resource estimation. While the URAG database was being brought into the WMGDP format, S.S. Gandhi developed his own global classification in large part derived from Dahlkamp (1993), included both in Gandhi (2007) and in this publication. Another globally-supported classification scheme has been evolving (OECD, 2014) under the auspices of the International Atomic Energy Agency (IAEA), and many of its categories correlate well with Gandhi (2007). However, not all of the deposits in the current database are covered in the 2014 system because the IAEA global uranium deposit database includes only major world class deposits. Classifications can be ambiguous: the distinguishing traits of several deposit types in both Gandhi (2007) and OECD (2014) may coincide in the same district, and even in the same deposit. Because of this, and because the Canadian U-Th-REE database includes many very small, poorly described occurrences, it was considered best to use the Gandhi (2007) system where possible, and to retain the original URAG descriptive categories such as vein or magmatic-anatectic for occurrences lacking additional information.

Data for a small number of select deposits world-wide were incorporated into this database to enable comparisons to Canadian deposits prior to the current release. Information about key unconformity-associated uranium deposits in Australia was included for the same reason in Gandhi (2007), which was otherwise focused on unconformity-associated deposits of the Athabasca Basin, Canada. The deposits chosen are mainly examples commonly referred to in company presentations and technical reports, such as Streltkovska, Russia, and Rössing, Namibia, and were originally derived from Finch et al. (1996) and IAEA|INFCIS (2012) and updated from available science literature. Although the present inclusion of the few non-Canadian deposits in this database is subjective and incomplete, maintaining records for well-studied world class examples might be useful in future to focus research questions that should be asked. However, they can easily be filtered for and deleted by an end-user.

As a final note of caution, at the time the URAG database was compiled, it was difficult to obtain exact locations for every deposit/occurrence, or to establish exactly what mineralization zone or piece of infrastructure was located in the data source. Many geographic coordinates were rounded to the nearest minute. Locations are therefore approximate for the most part, although recently it has been possible to use Google Earth™ to accurately locate some large open pits and infrastructure. It must also be emphasized that resource figures in this database are not current and do not comply with current standards for resource reporting [2]. They should be classified as <u>historical</u> resources and the original data source cited if they are re-reported. None fit the current definition of economic reserve.

The first version of this database appeared on Natural Resources Canada's Geoscience Data Repository web portal: World and Canadian Minerals Deposits in 2008. Geospatial excerpts from the database were made downloadable, and both these files and deposit/occurrence points were added to the map portal window and hot-linked to full deposit reports housed on an NRCan server. The only access NRCan is now planning to provide for World and Canadian deposit databases is through Web Map Services (WMS). The WMS have been used by external web map portals which display points with no attribute data as components of geospatial "mashups". The aim of this Open File is to make the full database and its supporting database management utilities available, and to provide simple attributed derivative ESRI® Shape and Google Earth™ kmz files, as well as folders of deposit and deposit group reports accompanied by index.html files that serve as Tables of Contents.

About GlobalDBSystem

The database schema (Chorlton et al, 2007) used for this database was developed for the WMGDP, and used to bring pre-existing but diversely structured mineral deposit and occurrence databases into a uniform structure for which the same database management tools could be used. The schema and the tools are together referred to as **GlobalDBSystem**. The web-style **Documentation** folder, modified from Laramée (2004), contains a thorough description of the WMGDP schema and supporting data management interfaces in the folder **GlobalDBSystem321**, and can be read using an Internet browser by clicking on the file **default.htm**. During the WMGDP, compilers (deposit specialists) and company sponsors suggested topics to be included in the schema. They also provided helpful feedback for the functionality of the data management interfaces. This resulted in incremental updates between releases to company sponsors. World and Canadian lode gold databases (Gosselin and Dubé, 2005a, b) were released in schema 3.19, the version used for the final release 3.6 to company sponsors in 2004. The schema, now at version 3.21, release 3.7, is a major update of version 3.19, with the addition of extra tables required for compilations under the Northern Resource Development and Northern Mineral Resource Development programs.

The GlobalDB System schema (diagram page 7) includes sets of tables that can be used to describe six entities (things): **deposits/occurrences**, **deposit groups**, **mines**, **production figures**, **resource figures**, and **references**. The deposits and deposit groups modules describe locations, deposit type and subtype, names, country and province, commodities, geological ages, host rocks, related igneous rocks, mineralization styles, coincident features, radiometric dates, tectonic settings, shape and dimensions, NTS areas, qualified comments, links to other databases, geophysical /geochemical signature, sample data, and compilation stage and progress. The service tables: entities, tabledoc, links, columndoc, tabpages, and lookup explicitly define the entities, tables, links between tables, fields, interface tab pages, and lookup tables, to completely define the schema. Two additional service tables: dbversion and unitcvsn, provide the title, version and authors of the current database, and conversion factors (to metric) for the production and resource figures, respectively. The service tables, described above, should be consulted before transferring this data across database management programs and platforms, or rebuilding the data management applications when the application interfaces supplied with this Open File can no longer be used because of changes to the Windows® operating system.

Standalone custom Windows® application interfaces, developed by Robert M. Laramée[3], enable a user with a 32 bit computer equipped with the Windows operating system to browse, filter, and obtain output from this database. These interfaces are included in this Open File in the folder **GlobalDBSystem321**. All applications require an ADO connection file, or Microsoft® data link, to each database for which they are to be used, and should for convenience be created in the folder that houses the application interfaces[4]. The GlobalDBSystem321 folder and files can be saved anywhere and no installation is required. Instructions for creating the mandatory Microsoft data link file are included under "**Defining database aliases**" in the **Documentation\default.htm** and in the standalone file **HowtoADO.rtf**.

GShellBrowser allows a user to browse the database record by record, and presents the same tab page view of the data offered by the original data entry interface, GShellADO, known in short form as **GShell**. The latter only works under the Windows® XP and earlier Windows operating systems, and has been included in this package for users who still have a Windows XP computer (disconnected from the Internet because Microsoft no longer supports it by supplying Security updates), or have an XP emulator installed. GQueryADO, known as **GQuery** for short, provides a user the means to filter the occurrences based on attribute values, to build a template for a custom spreadsheet and export this spreadsheet or a default summary spreadsheet, and to create folders of occurrence reports for the full set or subsets of the deposits in the database. Both GShellBrowser and GQuery work under Windows 7 on a 32 bit computer once the pre-requisite ADO connection file has been created.

There are three additional programs in GlobalDBSystem321: **GQ_ADO_XtraTables**, **Documenter**, and **GBDSTools**. The program GQ_ADO_XtraTables builds or rebuilds summary tables for the use of GQuery, which improved performance over an older method of creating these summary tables on the fly. The program Documenter allows users to examine each table and field of each category of table (Data, Junction, Lookup, and Service depending on their roles), which complements the more general web-style documentation. Finally, GDBSTools provides a database manager with utilities that can check the internal integrity of the database, time stamp a new release and export SQL data scripts of the contents of the connected database. These SQL scripts can be used to populate a new database created with GlobalDBSchema321.sql in one of many SQL-enabled relational database management systems available today[5].

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FOOTNOTES

[1]ACKNOWLEDGEMENTS

The World Minerals Geoscience Database Project (WMGDP) was carried out by the former Mineral Resources Division, Geological Survey of Canada (now Ore Systems, Central Canada Division, Geological Survey of Canada), with the support of the following industry sponsors: Anglo American plc, Barrick Gold Corporation, BHP Billiton Group, Cyprus Amax Minerals Company, Inco Ltd., Metal Mining Agency of Japan, North Ltd., Phelps Dodge Exploration Corporation, Placer Dome Exploration Inc., Randgold Resources Ltd., Rio Tinto Mining and Exploration Limited, Teck Cominco Limited and Western Mining Corporation. W. D. Sinclair managed this project on behalf of the Geological Survey of Canada, L. B.

Chorlton coordinated schema, tool development, and compilation, and R. M. Laramée implemented the schema, developed the applications for GlobalDBSystem, and provided technical support to compilers. The contributions from the WMGDP made the final form of this database and its partially automated export products possible.

However, it is the population of the database, regardless of the schema, that gives a database its real value. The entire staff of the former Uranium Resource Assessment Group, including Nirankar Prasad who maintained the contents of the Canadian Uranium and Thorium database, contributed immeasurably to the database contents by providing the seed data. The compilers are grateful to Catherine McCann for researching missing references for occurrences imported from the URAG database and to Gordon Bernius for checking and touching up entries for British Columbia and Manitoba.

[2]DISCLAIMER – RESOURCE/RESERVES DATA

Her Majesty the Queen in Right of Canada, represented by the Minister of Natural Resources (NRCan), does not warrant or guarantee the accuracy, completeness or fitness for any purpose of Reserve and Resource information (Data) contained in this database, including whether the Data is compliant with any securities regulations or standards, and NRCan does not assume any liability with respect to any damage or loss incurred as a result of the use made of the Data.

Resource and reserve figures are historical in nature. The Data source provided with each set of figures should be cited if the Data are re-reported.

[3] DISCLAIMER – APPLICATIONS AND DATABASE

The Geological Survey of Canada (GSC) has endeavored to develop and produce this product with a minimum of errors. GSC does not, however, warrant that the product is error free nor will GSC or its Minister and officials accept liability for any loss of profits or revenue, or any other form of loss or damage relating to the use of this product.

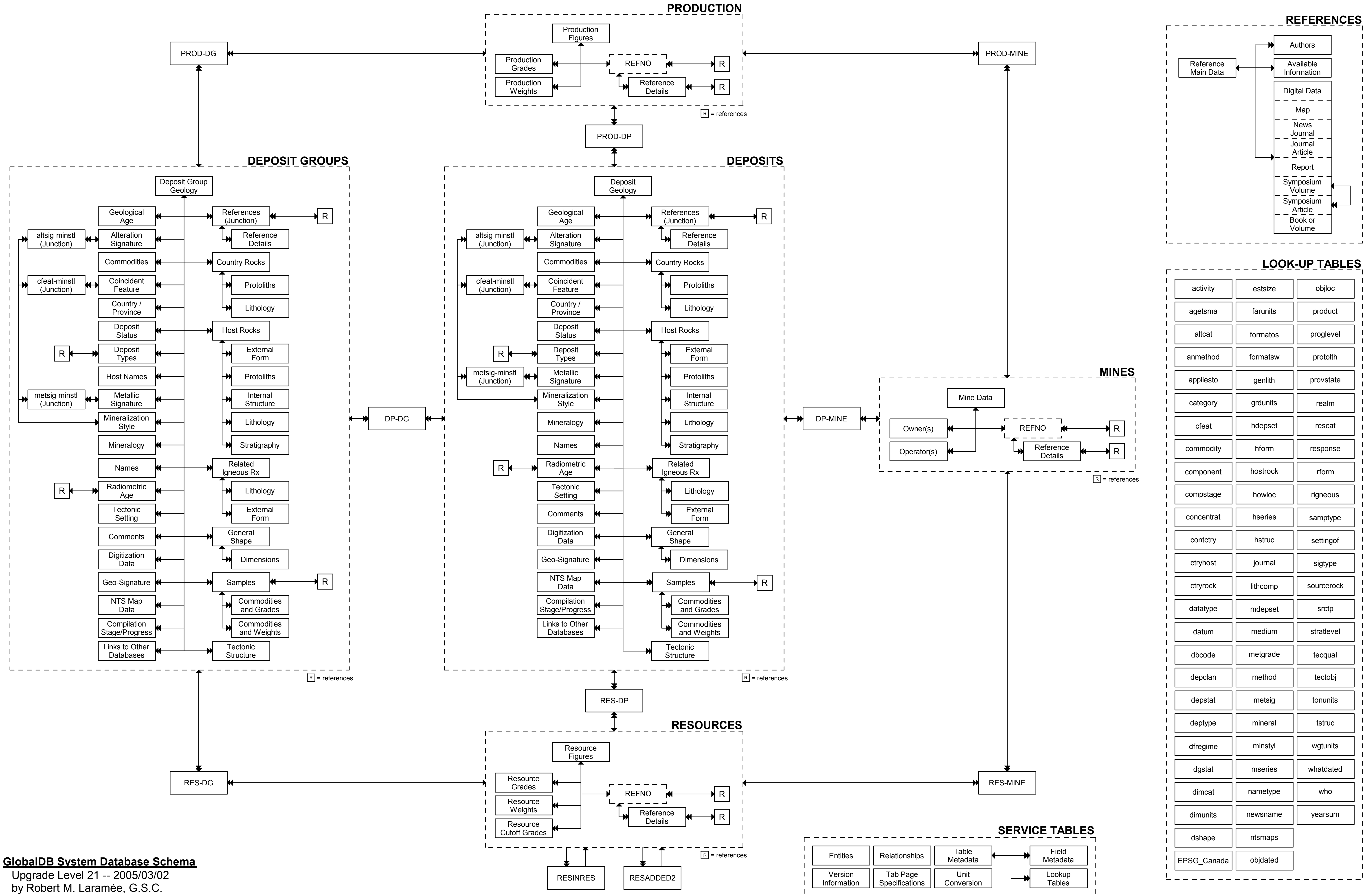
[4] CAUTION: UTILITIES MAY NOT WORK ON SOME WINDOWS COMPUTERS

While the WMGDP and successive projects have been successfully using Global DBSystem since the year 2000, there are now imitations due to the evolution of the Windows operating system and the introduction of 64 bit computers. In order to use GShellBrowser.exe, GQueryADO.exe, GQ_ADO_XtraTables.exe, Documenter.exe, and GDBSTools.exe, you must first create a data link file to allow connection between the program and the database (see "Defining database aliases" under Documentation). It is known that these instructions will not work on Windows 64 bit computers, and the interfaces will not work on computers with operating systems other than Windows®. At present, the data entry and browsing program GShellADO (GShell) will not work under Windows Operating Systems greater than XP, but is included here for anyone who might have an older operating system on a computer disconnected from the Internet or who has an XP emulator.

[5] LOADING A WMGDP DATABASE USING SQL SCRIPTS

SQL scripts are provided here for anyone with an SQL-enabled database management system (DBMS) and the technical skill to modify the scripts according to the requirements of their software. We have loaded the data onto InterBase and PostgreSQL for the use of applications that emulate GQuery for the Internet and the contents of folders for loading the schema reflect our own processes. There are subtle differences in the scripts for loading the database schema among DBMSs, and some tweaks applied to the schemas supplied in this publication were specific to the Query applications. The scripts for inserting the data into the empty database schema are standard, and only one insert script is supplied per database.

A, additional note of caution: it would be tempting to try to import the SQL contents of all of the mineral deposit databases in this Open File series (e.g. 7686, 7688, 7708, 7764, 7773, 7775 and so on) into one big database. This will not work because the entities of each separate database are indexed independently from each other, and were compiled on disconnected computers by compilers in many different places. In addition, the metadata file dbversion records different compilers and titles for each database. Thus, without substantial and careful re-indexing primary keys will clash between the different databases.



GlobalDB System Database Schema

Upgrade Level 21 -- 2005/03/02

by Robert M. Laramée, G.S.C.