

Enabling Semantic Interoperability between Mineral Deposit Descriptions from Different Provincial Databases

A CGKN/GeoConnections Project

Final Report

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EXECUTIVE SUMMARY

This is the final report on a GeoConnections-funded project entitled “Enabling Semantic Interoperability between Mineral Deposit Descriptions from Different Provincial Databases”.

The report explains why interoperability between systems which describe mineral deposits is important to scientific research, to governmental functions, and to minerals exploration.

It documents how semantic interoperability was achieved between the mineral occurrence databases of British Columbia (MINFILE), Newfoundland (MODS), and the MineMatch system for describing global mineral deposits and mineral deposit models.

Interoperability is demonstrated by comparing and similarity-ranking mineral deposits described on different provincial databases amongst each other, and with deposits and models from outside Canada.

Utilisation of the comparison and similarity ranking functions made possible by this project should make a substantial contribution to the understanding of, and classification of, the mineral deposits of British Columbia and Newfoundland, and to enhancements of the MINFILE and MODS database systems.

The role of standardized science languages in enabling semantic interoperability is highlighted, and the importance of current work by the Geological Survey of Canada in this regard is emphasised.

New computer programs and manual data processing methods are documented for extending semantic interoperability to other mineral occurrence and mineral deposit databases in Canada.

A new XML schema for the dissemination of mineral occurrence and mineral deposit data on the Internet is proposed.

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1

INTRODUCTION

This report describes a project entitled “Enabling Semantic Interoperability between Mineral Deposit Descriptions from Different Provincial Databases”.

The purpose of the project was to demonstrate how semantic interoperability between Canada’s provincial mineral occurrence databases may be achieved, and the advantages this interoperability offers to economic geologists once it has been achieved - in particular with respect to effectively comparing, and similarity-ranking, mineral occurrences and deposits.

Achieving semantic interoperability between large, long-existing databases is time-consuming difficult work, which does not, for the most part, make interesting reading for anyone but the database managers and administrators of the databases involved. Descriptions of this work have therefore been relegated to the Appendices of this report.

Section 2 of the report briefly discusses the importance of mineral deposit descriptions and classifications to governments and minerals exploration companies.

The advantages of implementing semantic interoperability between mineral occurrence databases are presented in the third section of the report, entitled “MODS and MINFILE Interoperation within MineMatch”.

Section 4 of the report examines exactly what it meant by “semantic interoperability”, and highlights the importance of “science language” work which is receiving attention in the Geological Survey of Canada, and other geological surveys.

Section 5 looks at the science language work in more detail.

Finally, Section 6 examines the role of XML in facilitating the achievement of semantic interoperability between autonomous mineral occurrence databases.

2

MINERAL DEPOSIT DESCRIPTION AND CLASSIFICATION

Classification schemes are important because they aid the communication of information between people. In economic geology, as applied to mineral deposits, they assist in efficiently making people aware of the similarities and differences between mineral deposits, and they play an important role in evaluating the mineral potential of different parts of the world.

A number of classification schemes have been proposed for mineral deposits, often having little in common with each other. For example, the British Columbia Geological Survey has developed its own comprehensive classification system, which may be reviewed on the Internet at <http://www.em.gov.bc.ca/Mining/Geolsurv/MetallicMinerals/mdp/mdphome.htm>. Example deposit types from the BCGS classification are shown below:

BC Profile	Deposit Type	Approximate Synonyms	USGS Model
I01	Au-quartz veins	Mesothermal, Motherlode, saddle reefs	36a
I02	Intrusion-related Au pyrrhotite veins	Subvolcanic shear-hosted gold	--
I03	Turbidite-hosted Au veins	Meguma type	36a
I04	Iron formation-hosted Au	Iron formation-hosted gold	36b
I05	Polymetallic veins Ag-Pb-Zn±Au	Felsic intrusion-associated Ag-Pb-Zb veins	22c, 25b
I06	Cu±Ag quartz veins	Churchill-type vein Cu	?
I07*	Silica veins	--	--
I08	Silica-Hg carbonate	--	27c
I09	Stibnite veins and disseminations	Simple and disseminated Sb deposits	27d,27e
I10	Vein barite	--	IM27e
I11	Barite-fluorite veins	--	26c*
I12*	W veins	Quartz-wolframite veins	15a
I13*	Sn veins and greisens	--	15b, 15c
I15	Classical U veins	Pitchblende veins, vein uranium	--
I16	Unconformity-associated U	Unconformity-veins, Unconformity U	37a
I17	Cryptocrystalline magnesite veins	Bone magnesite, Kraubath-type	--

Table 2-1
Some BCGS deposit types

In contrast to this system, the Newfoundland & Labrador Geological Survey has developed its own classification system, based heavily on its local geology. Example deposit types from the N&LGS classification are shown below:

Desc	DepType
All deposit types	0
Magmatic	
... Magmatic - hydrothermal deposit (porphyry - type)	65
... Magmatic - hydrothermal deposit (pegmatite association)	70
... Magmatic - hydrothermal (apalite association)	71
... Magmatic - hydrothermal (vein association)	75
... Magmatic - hydrothermal (skarn association)	80
... Magmatic - hydrothermal (greisen association)	85
Stratabound	
... Stratabound undivided volcanic deposit	101
... Stratabound undivided volcanogenic sulphide deposit	110
... Stratabound undivided volcanogenic sulphide in ophiolite	111
... Stratabound massive sulphide (± stockwork) in ophiolite	112
... Stratabound volcanogenic stockwork in ophiolite	113
... Stratabound volcanogenic sulphide - bearing breccia in ophiolite	114
... Stratabound undivided volcanogenic sulphide deposits in thick, mafic- dominated volcanic/epiclastic sequence	120

Table 2-2
Some Newfoundland & Labrador deposit types

One of the internationally better-known deposit classifications is that of the USGS¹, to which reference is often made, as in the case of the BCGS classification in Table 2.1.

The USGS classification is one of the few systems which specifically sets out to be global in scope.

This is surprising when one considers the importance of deposit classification systems to mineral inventory and prospectivity assessments, as carried out both by mineral exploration companies, and by governmental authorities in land-use planning.

One of the difficulties facing these assessments is their dependence on a knowledge of the grade and size distribution of different deposit types. Since economic mineral deposits are scarce, compiling reliable estimates of these statistics is a challenge. The global utilization of the same mineral deposit classification system would significantly assist in addressing this challenge. It would improve the accuracy of mineral inventory and prospectivity analyses, and all the planning activities, in both public and private sectors, that they affect.

The deposit-type cross-referencing evident in Table 2-1 is an important “first-step” towards this goal.

¹ Originally authored by Cox and Singer (1986), these models have been revised and extended at various times since 1986. Refer: <http://minerals.cr.usgs.gov/team/depmod.html>

Since mineral deposits and occurrences must be classified on the basis of descriptions, it follows that their classification will be much more accurate if mineral deposits and occurrences are described using the same criteria and terminology.

The “MineMatch” system provides standard terminology for the description of mineral occurrences and deposits, and provides the same terminology for the description of mineral deposit types, or models. Further, MineMatch can rapidly classify mineral occurrences and deposits according to the deposit types they most closely resemble.

MineMatch therefore directly addresses the most significant challenge facing improved prospectivity and mineral inventory analyses: the generation of mineral occurrence and deposit descriptions using a standard vocabulary.

The translation, accomplished as part of this project, of more than 17000 Canadian mineral occurrence and mineral deposit descriptions into the standard terminology offered by MineMatch is therefore a significant contribution towards refining our understanding of mineral deposit classes, and towards improving the accuracy of mineral inventory and prospectivity analyses, both in Canada, and elsewhere in the world.

It prepares the ground for valuable research work which would not previously have been affordable, and is likely to have a feedback effect on the future development of both MINFILE and MODS.

3

MODS AND MINFILE INTEROPERATION WITHIN MINEMATCH

MineMatch is a system designed for use by economic geologists in their research studies of known mineral deposits, and in their search for new deposits. The system is described at the www.georeferenceonline.com website, in a pamphlet in Appendix D of this report, and in the comprehensive documentation built into the software system itself.

This section will briefly demonstrate how MODS and MINFILE descriptions, be they of small mineral occurrences or large mines, can be used together in MineMatch to produce results and reports of significant value to economic geologists, and, in some cases, environmental workers.

The production of equivalent results and reports without first transferring the MODS and MINFILE descriptions into MineMatch requires so much time and money as to be prohibitive to most researchers and explorers.

Finding Deposits in Newfoundland Similar to a Deposit in B.C.

Figure 1 shows a listing of all mineral occurrence and deposit descriptions in MINFILE in the left window of MineMatch, and all those in MODS in the right side window.

Figure 2 shows the system scanning the MODS database for descriptions matching the description of the MINFILE “093L 089 Dome” occurrence. The scan was initiated by the following three simple actions:

- (a) Double-clicking on the “093L 089 Dome” entry in the list in the left side window of Figure 1 to make it the “In Focus” description;
- (b) Clicking in the uppermost checkbox in the right side window of Figure 1 to select for comparison all the entries in the list of Newfoundland descriptions;
- (c) Clicking on the right-pointing arrow in the MineMatch toolbar to initiate a comparison of the “In Focus” description in the left window with all the descriptions selected in the right window.

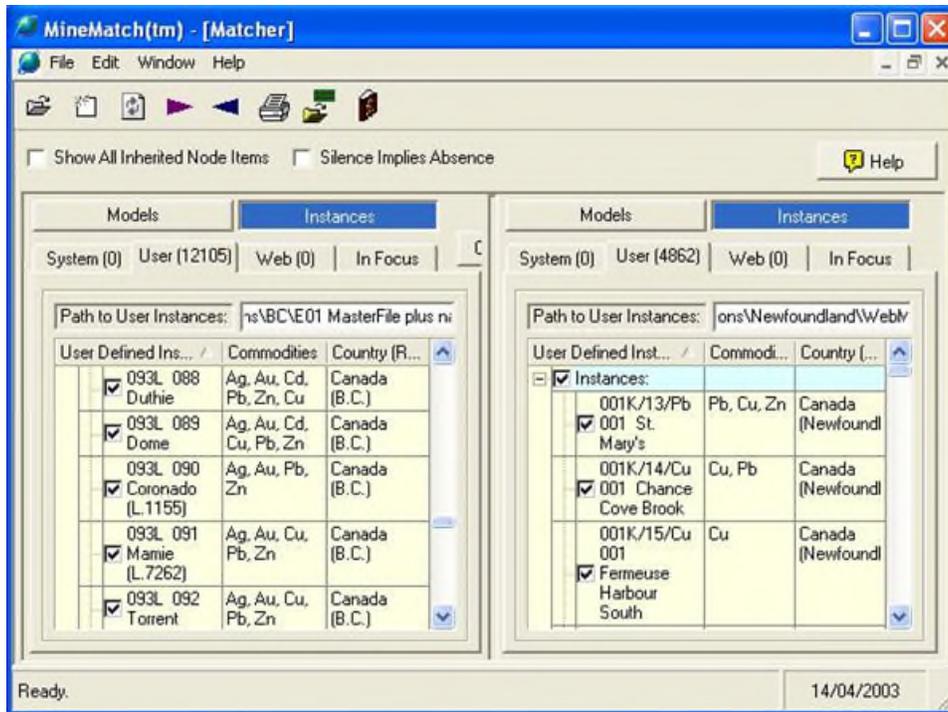


Figure 1 Complete lists of MINFILE and MODS descriptions side-by-side in MineMatch

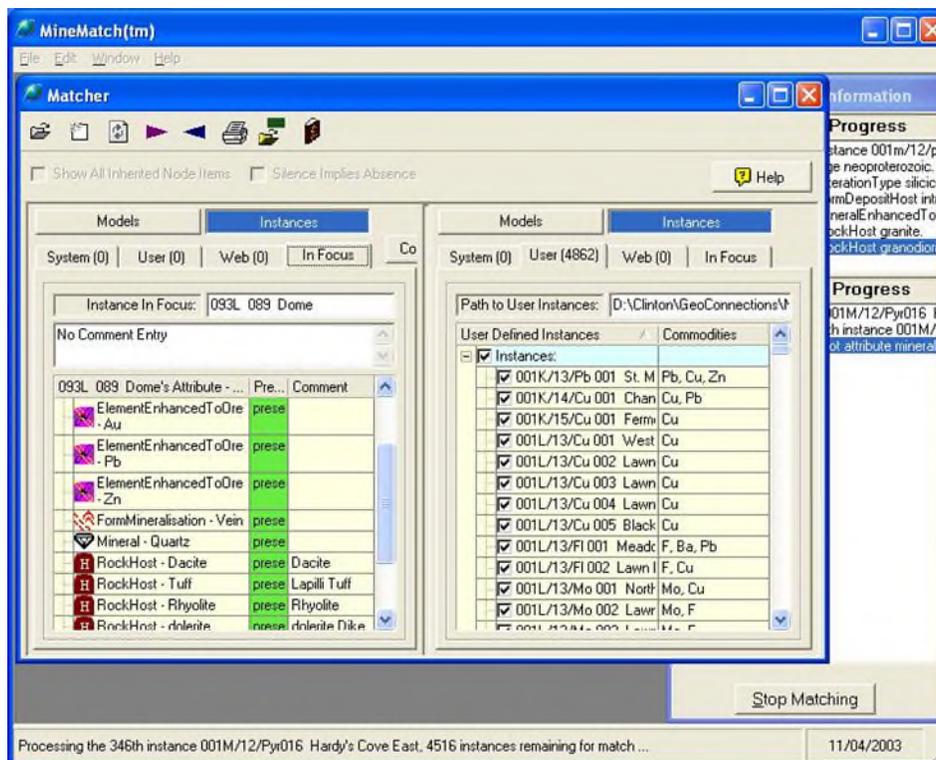


Figure 2 Screenshot showing MineMatch comparing MINFILE's "Dome" description to 4862 descriptions from the MODS database.

The Figure 3 below shows the comparison results, with the “Tulks East Deposit” description emerging as most similar to MINFILE’s “Dome” description.

Match Object	Rank	Overall Score	Penalties	Rewards
012A/11/Zn 002 Tulks East Deposit	1	50	512	70000
012A/15/Zn 015 Middle Branch Prospect	2	43	400	60000
012A/09/Zn 010 Duck Pond Deposit	3	43	515	60000
002E/12/Cu 001 Pilley's Island Mine	4	43	606	60000
002E/12/Zn 007 Bull Road Showing	5	39	708	55000
002E/10/Cu 006 Moreton's Harbour Head	6	36	604	50000
012H/09/Zn 001 Indian Brook	7	36	604	50000
012H/09/Cu 023 Muir Pond	8	36	605	50000
012A/15/Zn 007 Two Level Orebody	9	36	606	50000
012A/10/Zn 012 Lemarchant	10	36	606	50000
012A/15/Zn 004 Rothermere	11	36	607	50000
012A/15/Zn 005 MacLean	12	36	607	50000
012A/15/Zn 003 Oriental #2	13	36	608	50000
002E/12/Zn 003 Shamrock	14	36	616	50000
012A/15/Zn 001 Lucky Strike	15	36	707	50000
012A/09/Zn 011 Boundary Deposit	16	36	719	50000
002E/12/Cu 007 Bull Road Extension	17	36	806	50000
002E/06/Cu 007 Little Northern Harbour	18	32	704	45000
002E/10/Cu 004 Wild Cove	19	32	706	45000
001M/03/Au 001 Kelstone	20	32	706	45000
002E/12/Zn 006 Bull Horn Prospect	21	32	706	45000
002E/12/Au 001 Hearn Prospect	22	32	707	45000

Figure 3
Similarity ranking results after comparing MINFILE’s “Dome” description to all descriptions in the MODS database.

Comparisons are ranked on “Overall Score”, which is normalized to a range of 0 to 100. One hundred signifies a perfect match, and is the score returned if a description is compared with an identical copy of itself. Before normalization, scores are calculated by accumulating rewards for matching attribute values (subject to downscaling depending on how well attributes or their values match²) and penalties for conflicting attributes.

MineMatch’s side-by-side comparison of the “Dome” description with its best matching description in the MODS database is shown in Figure 4 overleaf. A number of querying, explanation, documentation and reporting functions are available to the user on the comparison form. From the selection box which also stores the ranking list in the top right-hand corner of the form, side-by-side comparisons with any other Newfoundland descriptions may be requested.

² MineMatch’s scoring methodology is explained in detail in the MineMatch documentation, and in a technical paper available for download from the www.georeferenceonline.com web site.

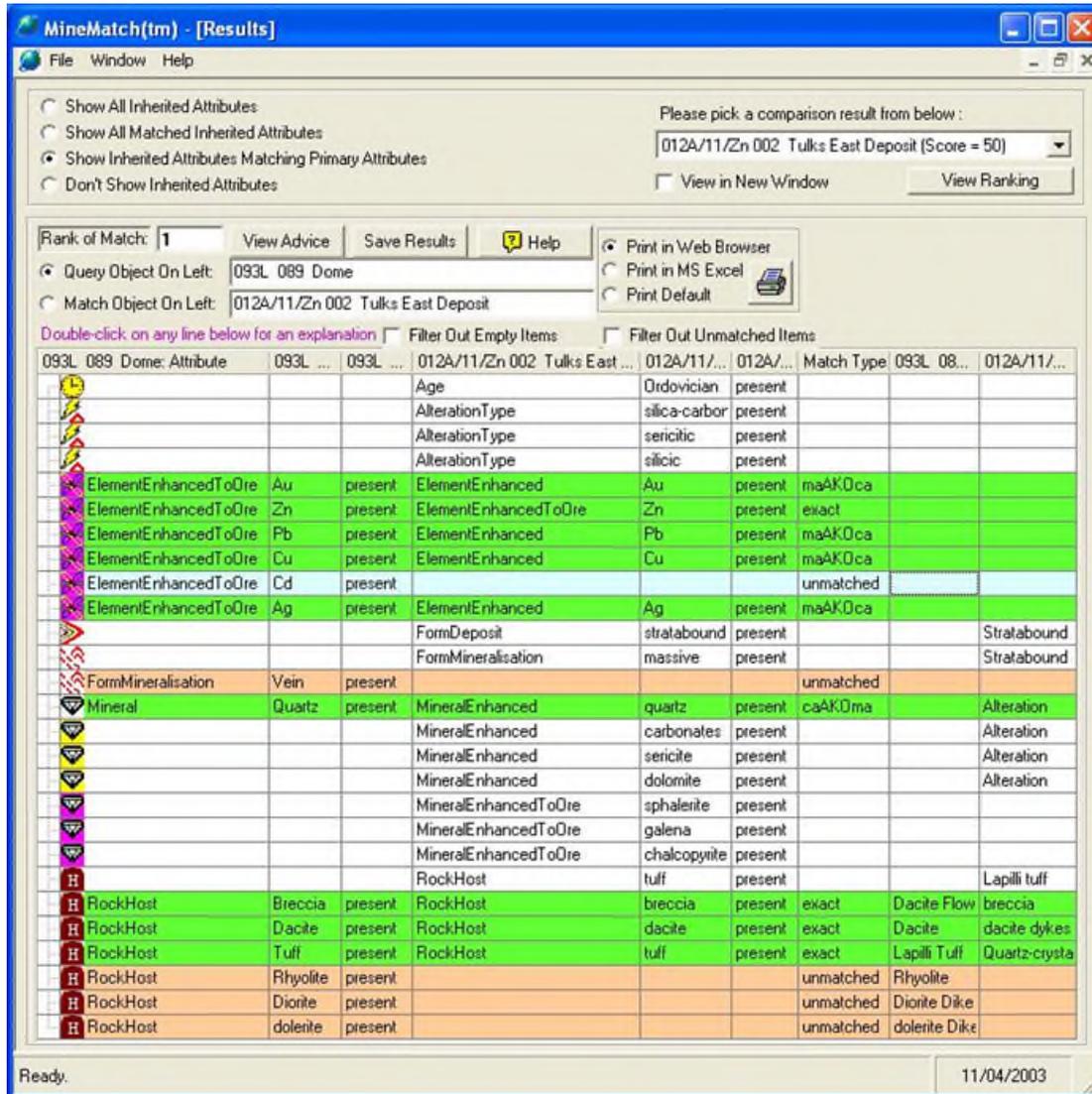


Figure 4 Detailed comparison of MINFILE's "Dome" and MODS' "Tulks East Deposit" descriptions.

Finding Mineral Occurrences in Newfoundland similar to Australia's Ernest Henry Deposit

Figure 5 is a composite of screenshots, similar to those above, illustrating the use of MineMatch to seek MODS descriptions which are most similar to a detailed MineMatch description of the famous "Ernest Henry" deposit in Australia (IOCG-type). This illustrates the ease with which the MODS descriptions in MineMatch can "intereoperate" with the many descriptions in MineMatch of foreign deposits which have shaped global thinking on minerals deposits.

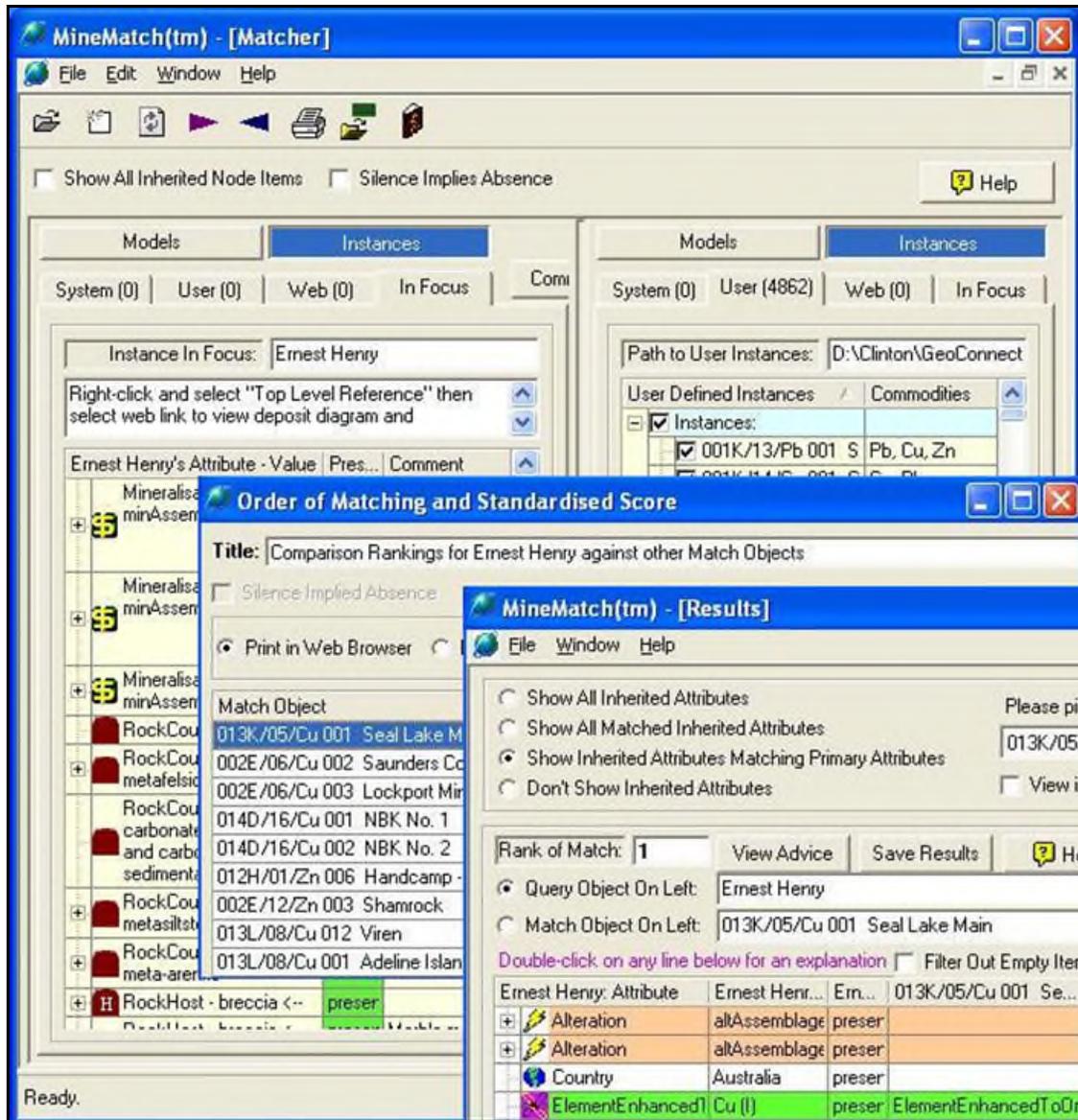


Figure 5
 Composite of MineMatch screens showing the search within MODS for mineral occurrence/deposit descriptions similar to the Australian Ernest Henry deposit.

Classifying a Mineral Occurrence in Newfoundland using the USGS Classification

Figure 6 illustrates the use of MineMatch to assist with the classification of mineral occurrences.

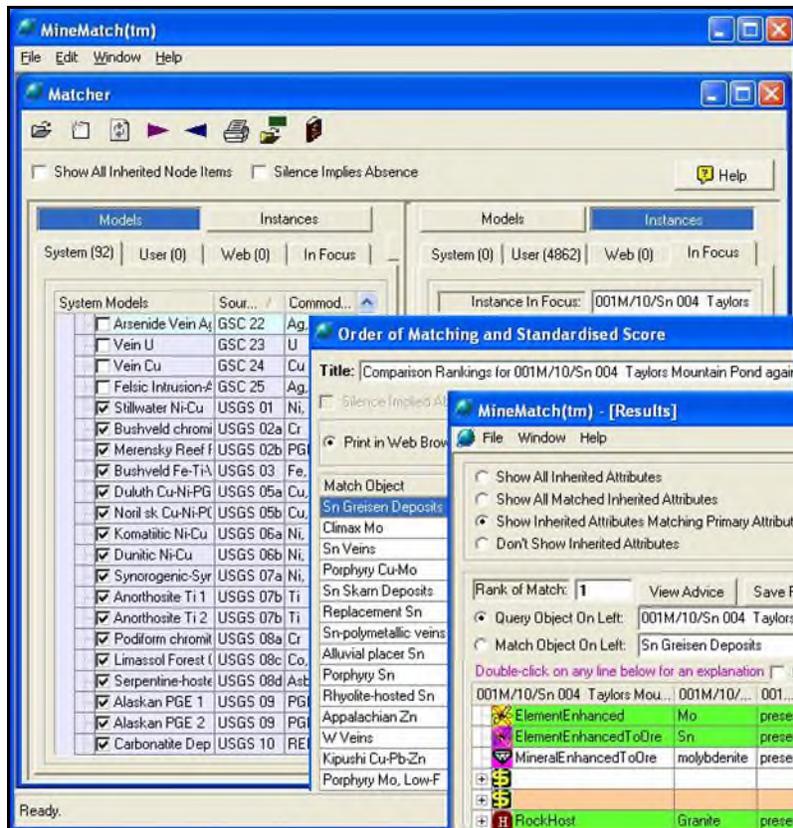


Figure 6
Using MineMatch to classify a MODS mineral occurrence description using the USGS Mineral Deposit Classification System.

In the right-side window (rear layer of Figure 6), the mineral occurrence of interest was placed “In Focus”, and in the left-side window all (and only) the USGS Mineral Deposit Type Descriptions were selected for comparison.

The middle layer of Figure 6 shows USGS deposit models matching the occurrence, in decreasing order of similarity, and the top layer shows part of MineMatch’s side-by-side comparison with the best-matching model.

MineMatch does not claim to always make the “correct” classification. However, the organized manner in which it presents supporting data, and the explanations it can give on how it derived its rankings, usually provide valuable insights into the mineral occurrence of interest. Further, clicking on the “Advice” button will cause MineMatch to advise the user on how additional information about the occurrence will improve or worsen the match.

Finding “Zinc Skarn-Type” Mineral Occurrences in Newfoundland, as defined by the BCGS

Figure 7 illustrates the use of MineMatch to seek MODS descriptions which are most similar to the B.C. Geological Survey deposit model for “zinc-lead skarns”. Like the previous examples, this illustrates how MODS descriptions in MineMatch can “intereoperate”, in a time and money-saving manner, with internationally accredited mineral deposit classification systems, for both research and exploration purposes.

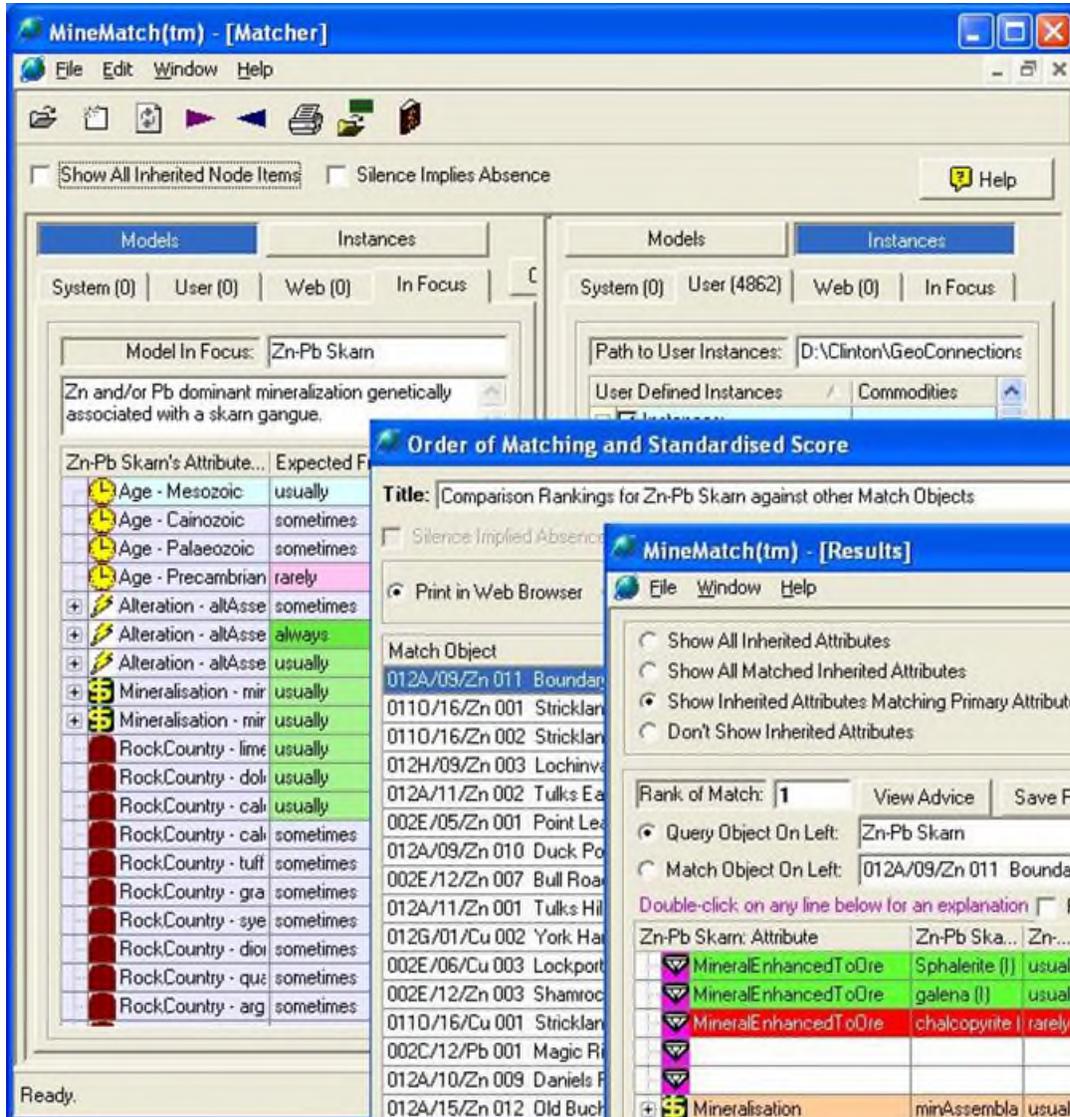


Figure 7
Composite of MineMatch screens showing the search for Zn-Pb Skarn-type deposits in the Newfoundland MODS database.

4

SEMANTIC INTEROPERABILITY

Interoperability is defined by the Merriam-Webster Online Dictionary as “The ability of a system to use the parts or equipment of another system”. Interoperation between software systems is closely related to the data produced by one system, for use by another, and may be considered in at least three different contexts: format interoperability, locational interoperability, and semantic interoperability.

Format interoperability deals with the relationship between the different formats in which data may be successfully exchanged between systems, and sometimes human beings. The XML format, discussed in Section 6 of this report, has the important characteristic that, as well as being readable by an increasing number of software systems, it is also readable by human beings.

Locational interoperability deals with the consistency, or “inter-relatability”, of spatial attributes, as they are handled by different systems. Two spatial data sets located using the same co-ordinate framework are spatially, or locationally interoperable. They may also be interoperable, in regard to a specific software system, if they are in different co-ordinate systems, but the software system knows the exact nature of the relationship between the two co-ordinate systems, and can implement the necessary transformations to bring them into the same framework.

Semantic³ interoperability deals with the consistency, or “inter-relatability”, of semantic attributes exchanged between systems.

Semantic interoperability between systems may be achieved by ensuring that the systems use exactly the same terminology, or, if they do not, by ensuring that they are able to utilize a mapping of one terminology onto the other, so as to effectively be working with a common terminology. Achievement of interoperability by the latter method may involve the loss of information.

An example of the problem is provided by comparing the terminology employed by MineMatch for “Alteration Type” with that employed by Newfoundland & Labrador’s MODS system, as shown in Figure 8 overleaf.

[The comparison is presented in the “Treelist Editor” utility, which was specially designed for the development and comparison of hierarchical taxonomies. The utility is available at <http://www.georeferenceonline.com/treelisteditor>]

³ “Of or relating to meaning in language” (Merriam-Webster Online Dictionary).

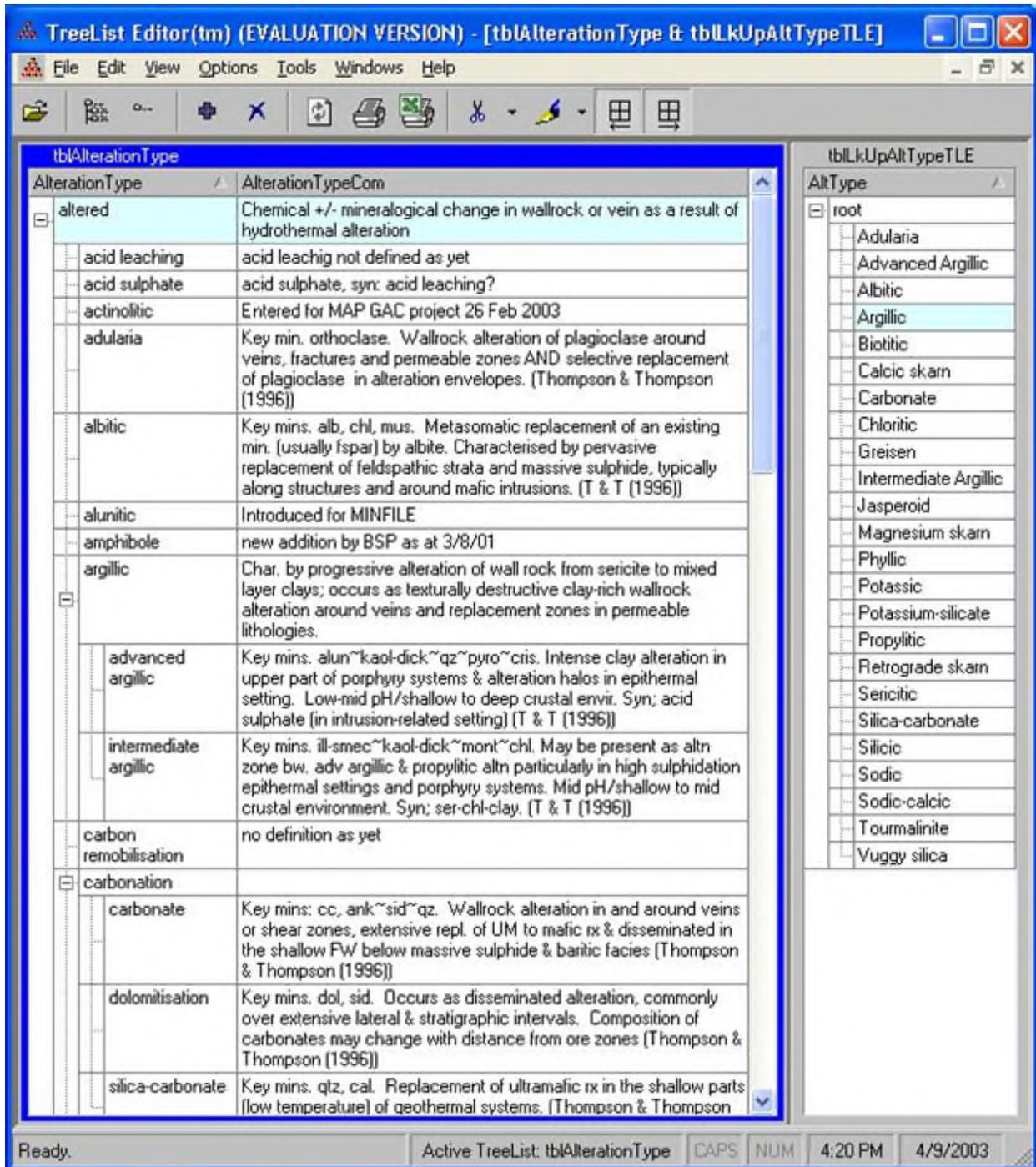


Figure 8
Comparison of “Alteration Type” terminology used by MineMatch (left) and MODS (right).

On close examination, it was possible to map all alteration type terms in the MODS vocabulary to equivalent terms in the MineMatch vocabulary, without any loss of information – this, despite the absence of definitions of alteration type terms in MODS. (Most of the MineMatch alteration type definitions are taken from the “Atlas of Alteration” by Thompson and Thompson (1996).)

Comparison of the MineMatch alteration type vocabulary with that of MINFILE, however, yielded a few terms which could not be mapped to the MineMatch vocabulary, and were therefore added to it (eg: “alunitic” in Figure 8). These terms then become available for all future descriptions entered into MineMatch.

The situation was more complicated for rock types.

MineMatch currently uses the British Geological Survey Rock Classification System, which attempts to be as non-genetic as possible (<http://www.bgs.ac.uk/bgsrscs/home.html>).

MINFILE uses a highly expressive combination of (controlled) base rock names and qualifiers for the description of host rocks, which leads to 3315 unique host rock names⁴ in the database.

MODS, on the other hand, allows free text of up to 255 characters, which has led to the presence of 2280 unique host rock descriptions in the database. When the descriptions are parsed for unique comma-delimited phrases, the number reduces to 1617 rock types, in a database of around 4500 mineral occurrences.

Figure 9 overleaf compares the first few rock types occurring in MINFILE and MODS.

Clearly, interoperation between systems using such different vocabularies to describe rocks is impossible without significant efforts to cross-relate the terms and phrases used in each system.

The appendices of this report document these efforts, which have resulted in interoperable version of both databases.

However, of far greater value to the users of MINFILE, MODS and MineMatch in the long term would be the adoption by all three systems of the same system of rock nomenclature (taxonomy).

This raises the question of which taxonomy to adopt – a subject receiving considerable attention at this time in the Geological Survey of Canada, the USGS, and the British Geological Survey, as well as in other geological institutions, under the heading “Science Languages”.

Science languages are discussed in the next section.

⁴ These can be viewed by using the GeoConverter1 program (Appendix A) on the “RockHost” field of the “MINFILEinACCESS – populated.mdb” file, available on the accompanying CD.



Figure 9
Comparison of rock types occurring in MINFILE and MODS

5

SCIENCE LANGUAGES

In Section 2 of this report, the case was made for the use, throughout Canada, of a single globally applicable mineral deposit classification system. It was pointed out that such a classification would need to be built upon descriptions of mineral deposits using standard terminology.

The need for standard terminology was further developed in Section 4 in the context of semantic interoperability. Some of the pre-requisites for semantic interoperability, it was shown, are common, or cross-mapped, geological taxonomies.

The fundamental role taxonomies play in the communication and development of scientific knowledge has been highlighted by the connectivity provided by the Internet. The Internet has shown that, even though we can now connect databases located in different parts of the world in real time, we cannot exploit those connections to further our knowledge because the connected databases are built on different semantics. The most fundamental difference in semantics limiting the interoperation of database systems arises from the non-standard taxonomies we use for naming the objects we work with.

As a result, various teams around the world are now working to produce new, standard, taxonomies.

The GSC has recently published two research papers in this regard:

- (1) "Hierarchical classification of tectonic assemblages for use with thematic, computer-based, query systems: a preliminary scheme" by Struik and Quat (2002)
- (2) "A preliminary scheme for multi-hierarchical rock classification for use with thematic computer-based query systems" by Struik et al (2002)

Both have great relevance to aiding the description of mineral deposits with standard terminology. Unfortunately, neither is complete.

We present the GSC-proposed "Tectonic Assemblage Classification", shown in Figure 10 overleaf as an example. The proposed classification is incomplete because it is without definitions of the different classes in the hierarchy.

To illustrate the importance of accompanying definitions, Figure 11 shows the "Tectonic Setting" and "Sedimentary Setting" classifications currently used in MineMatch, together with their definitions, as provided by the authors of the classifications. It is clear from the definitions that the different authors understand different things for the same word (example: "back arc").

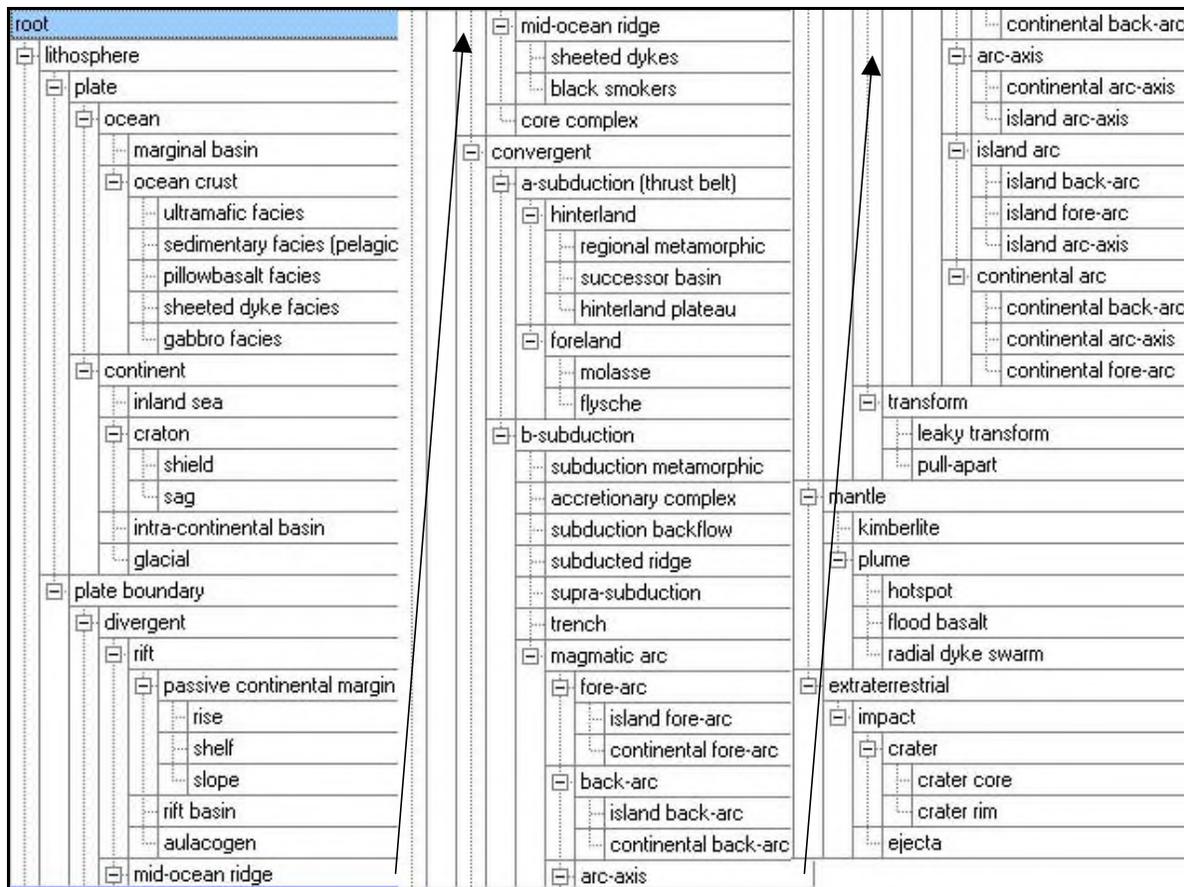


Figure 10
Classification of Tectonic Settings proposed by the GSC (Struik and Quat, 2002)

This difference in understanding does not become evident until “understandings” are committed to writing.

When Canada’s standard taxonomies are completed, however, they will not be the only “standards” to choose from. The USGS (<http://geology.usgs.gov/dm/terms/>) is also working on a new hierarchical rock classification system, and, as discussed above, the British Geological Survey has already published one.

Interoperability will therefore require mappings between these emerging, competing standards, for the foreseeable future. It must be hoped that these mappings will be achieved with minimal data loss (as in the case of “Alteration Types” discussed in the previous section), and without the complexity evident in the mapping of the MINFILE and MODS rock description terms to those used in MineMatch (also discussed in the previous section).

This report provides documentation of:

- (a) the advantages of taxonomy standardization (Sections 2 & 3), and

- (b) the cost (Section 4) of not using standard terminologies in different provincial databases targeted at exactly the same objects (mineral occurrences)

This evidence of the advantages of action and the costs of inaction is strongly supportive of providing additional resources to the current science language standardization initiatives in the GSC.

Setting	SettingCom
arc systems	Volcanic island chains developed on oceanic crust or continental margin volcanic chains developed on continental or transitional crust above active subduction zones ideally consisting of an arc-trench gap, the arc and the arc-rear area (Condie)
trench	Very deep, narrow, extensive, linear, sediment poor structure formed in the ocean floor parallel to arc systems above where a lithospheric slab begins to descend into the mantle and subject to intense seismic activity (Condie)
retroarc foreland basin	Continental margin arc-rear basin filled with syntectonic clastic terrigenous sediments from the fold thrust belt which becomes involved with the proximal margin + gives inversestratigraphic sampling as unroofing progresses (Condie)
remnant arc	Extinct arc portions forming submarine aseismic ridges rifted away by opening of back-arc basins (Condie)
forearc basin	Marine turbidite depositional basins up to 700km long overlying and arc-wards of the accretionary prism and lacking volcanism (Condie)
back-arc basin	Behind arc over descending oceanic slabs, if active have high heat flow and thin often ophiolitic lithosphere and an ocean ridge enlarging the basin dominant sediments proximal (Condie)
arc	Subaerial and submarine volcanic chains erupting tholeiitic and calc-alkaline magmas above a descending oceanic slab (Condie)
accretionary prism	Steeply inclined melanges of sediment and volcanics including slab derived ophiolites as fault-bounded wedges accreted to the arc front above a descending oceanic slab (Condie)

Figure 11
Tectonic setting definitions from Condie (1997)

Setting	SettingCom
convergent	
trenches	Deep troughs formed by subduction of oceanic lithosphere
trench-slope basins	Local structural depressions developed on subduction complexes
retroarc foreland basins	Foreland basins on continental sides of continental-margin arc-trench systems (formed by subduction-generated compression and/or collision).
remnant ocean basins	Shrinking ocean basins caught between colliding continental margins and/or arc-trench systems, and ultimately subducted or deformed within suture belts.
piggyback basins	Basins formed and carried atop moving thrust sheets
peripheral foreland basins	Foreland basins above rifted continental margins that have been pulled into subduction zones during crustal collisions (primary type of collision-related forelands).
intra-arc basins	Basins along arc platform, which includes superposed and overlapping volcanoes.
foreland intermontane basins	(Broken forelands) Basins formed among basement-cored uplifts in foreland settings.
fore-arc basins	Basins within arc-trench gaps.
back-arc basins	Oceanic basins behind intraoceanic magmatic arcs (inc interarc basins between active and remnant arcs) and cont. basins behind cont. margin magmatic arcs without foreland foldthrust belts

Figure 12
Sedimentary setting definitions from Ingersoll and Busby (1995)

6

THE ROLE OF XML

An XML Schema for Canadian mineral occurrences was proposed in the final report of the CGKN's "Geo-Science GML Encoding Report"⁵.

While the report made some important recommendations, in particular relating to an XML/GML format for interoperable mineral deposit databases, and relating to the use of standard term dictionaries, details of the proposed schema are difficult to assess because they are buried in the schema itself. Even using the most modern XML Schema-viewing tools (XMLSpy 5), because of the schema's considerable depth, schema details cannot be presented to an evaluator in a satisfactory layout.

Simply viewing example data stored according to the recommended schema would assist in understanding the semantics of the stored data, and hence give some insights into how it must be stored in the back end. Unfortunately, however, no good stylesheet for viewing the four sample mineral occurrences entered into the recommended XML format is available.

The only stylesheet that is available is embedded in the Javascript which controls the mapping demonstration given by the contractors (Galdos Systems Inc) at the end of the project. Galdos kindly provided the author with web access to the demonstration, from which it was possible to print output from the example XML data, as it was rendered in one of the browser frames which make up the demonstration. An example of this output is presented in Appendix E.

Our view of the proposed schema is that it is inadequate for the interoperability goals both of this project, and the goals of any other users needing to access the mineral occurrences data for all but the simplest of purposes (such as human review, or rendering in response to very simple queries within a Geographic Information System). This is because its design lacked an ontological analysis⁶ of the knowledge domain it addressed.

The case for engineering ontologically-based, XML-formatted views of legacy databases as data sources for future web-based applications is clearly made in the writings of Bertram Ludäscher at <http://www.sdsc.edu/~ludaesch/Paper/presentations.html>. It is summarised in the following diagram taken from his presentation at <http://www.sdsc.edu/~ludaesch/Paper/ahm03-data-mediation.ppt>.

⁵ Final Report [TR2002-213-02; Galdos Systems Inc.; 6 May, 2002]

⁶ See "Ontology Development 101: A Guide to Creating Your First Ontology", (Noy and McGuinness(2000)) available at http://protege.stanford.edu/publications/ontology_development/ontology101.pdf Also: "What are ontologies and why do we need them ?" (Chandrasekaran et al (1999))

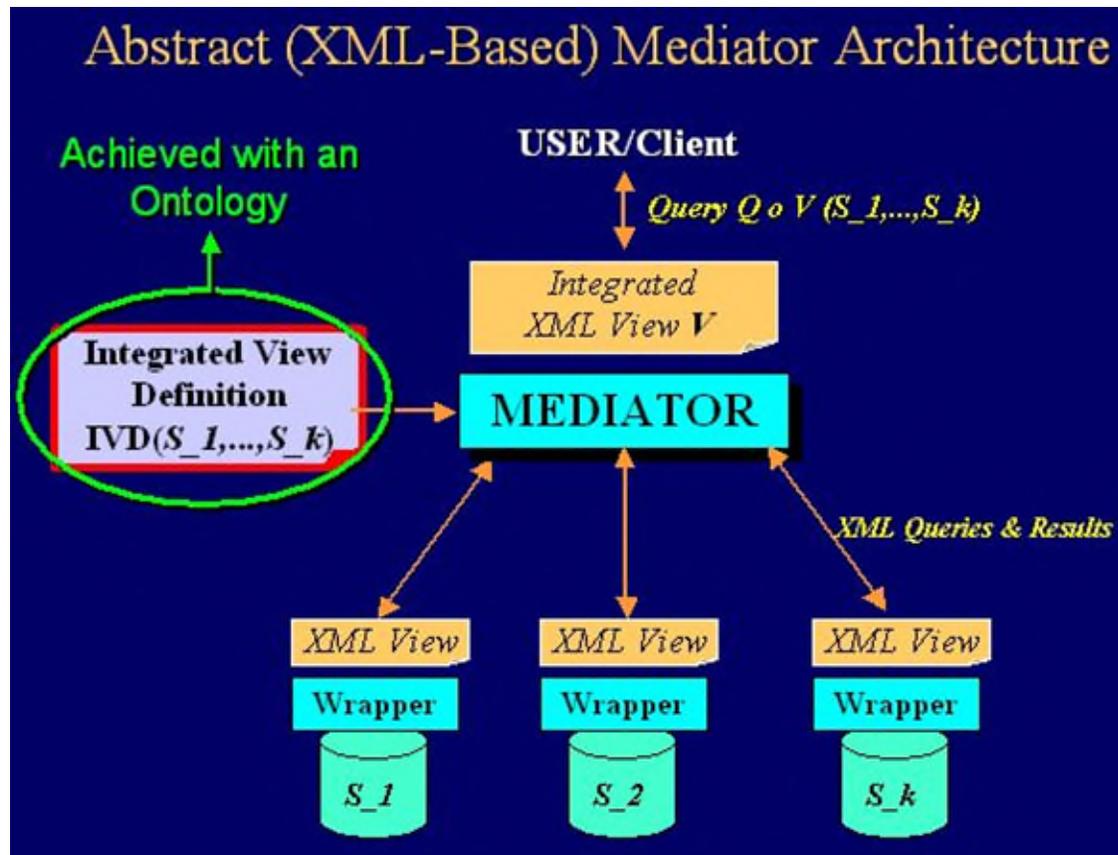


Figure 13 Diagram (Ludäscher, 2003) illustrating the role of XML in data mediation.

In the light of this project’s experience with the previously proposed XML schema, and mindful of the directions in which data formatting preferences are moving, a different (GML-compatible) XML schema was developed for MODS and MINFILE data, which is compatible with MineMatch.

The schema (MM001.xsd) may be found on the accompanying CD, along with an example XML file containing three MineMatch descriptions (MM001.xml), and an XML stylesheet (MM001.xslt) for rendering the XML into HTML. XML files containing single or multiple MODS or MINEFILE descriptions may be created using the MineMatch “XML ” capability, and read back into MineMatch using its “XML Read” capability.

Browser-rendered extracts of the three uniquely formatted regions of the XML data structure are presented in Figures 14 to 16, and described below.

The first region of the XML file, presented in Figure14, stores a list of the descriptions which are within the XML file, together with summary information about each description.

Title	Source	Commodities	Country (Region)	Comment	USGS1	USGS2	USGS3
Rosia Poieni	GEODE	Cu, Au, Mo	Romania	ABCD Group. One of the mines in the	Porphyry Cu-Mo	Porphyry Cu	Phanerozoic IOCG
Uzelga	GEODE	Cu, Zn	Russia	Urals Group. One of 58	Kuroko massive sulph	Phanerozoic IOCG	Porphyry Cu
Voznica-Zlatno 2	GEODE	Cu, Au	Slovakia	ABCD Group. One of the mines in the	Porphyry Cu	Phanerozoic IOCG	Merensky Reef PGE

Figure 14
Region 1 of an XML MineMatch file: List of contained descriptions, with some meta-data.

The second region of the file stores the descriptions themselves, and is rendered in Figure 15 below. It shows the first few attributes/value pairs of the Uzelga deposit, associated comments, contact details of the person who input the description, and a Reference ID uniquely identifying the source of each recorded fact, which is recorded elsewhere in the file, as shown in Figure 16.

ID / PID	Attribute	Value (Freq)	Comment	Contact Info Reference ID
1 / 0	Instance	Uzelga (instance)	One of 10 mines in the LODE Ural	<ukbrianking@btinternet.com> {12619954-B9CD-4E60-9D2F-E56E10B49910}
2 / 1	Age	Eifelian (present)	Both host rock and mineralisation age.	<ukbrianking@btinternet.com> {7801B2A6-9EFD-11D6-98C5-F9CE85476030}
69 / 4	FormMineralisation	lenses (present)		<ukbrianking@btinternet.com> {7801B2A6-9EFD-11D6-98C5-F9CE85476030}
4 / 1	Mineralisation	minAssemblage 1 (present)	Stringers not in MineMatch	<ukbrianking@btinternet.com> {7801B2A6-9EFD-11D6-98C5-F9CE85476030}
5 / 4	ElementEnhancedToOre	Cu (present)		<ukbrianking@btinternet.com> {7801B2A6-9EFD-11D6-98C5-F9CE85476030}

Figure 15
Region 2 of an XML MineMatch file: Deposit/Occurrence description details.

The third region of the file, rendered in Figure 16, is effectively a bibliographic database storing the source of all facts recorded in the descriptions.

Reference ID URL	Title Authors (Year)	Publication	Notes
{12619954-B9CD-4E60-9D2F-E56E10B49910} http://www.goli.ca/MineMatchRef/LODE/UzelgaZones.xls	"Uzelga worksheet" B H King (2002)	GeoReference Online Ltd	Internet Explorer and Excel required
{2D38CD24-9FE6-11D6-98C5-E55E191B3030} http://www.gl.rhbnc.ac.uk/geode/ABCD/A.puseni.html	"Apuseni District" L Rajavuori (2001)	GEODE LODE web site database	
{415B1B6D-6D7E-4FDB-B0D2-10CC0F14F89B}	"Not Applicable" System ()		reference used for inherited
{7801B2A6-9EFD-11D6-98C5-F9CE85476030} http://www.gl.rhbnc.ac.uk/geode/cbase.html	"Uzelga" R Herrington (2001)	European Science Foundation	Most GEODE web pages include
{82D825AB-A858-11D6-98C5-C8E0B38EC830} http://www.gl.rhbnc.ac.uk/geode/ABCD/Hodrusa.html	"Hodrusa" L Rajavuori (2001)	European Science Foundation	geological plans and photographs of

Figure 16
Region 3 of an XML MineMatch file: Reference sources.

The schema is clearly only a partial specification of what would be required to accommodate all the data which appears in the MINFILE and MODS databases. It addresses only the needs of the information used by MineMatch.

However, because the schema is significantly different from the previously proposed schema, and because its designers believe it presents new design elements necessary for the web services philosophy presented in Figure 13, and targeted by the CGKN and GeoConnections, it has been included in this report.

GeoReference Online Ltd would be pleased to assist with the extension of the schema to include data necessary to users of MODS and MINFILE, but not necessary to the purposes of MineMatch.

7

CONCLUSION

Interoperability between systems which describe mineral deposits is important to scientific research, to governmental functions, and to minerals exploration.

This project has implemented semantic interoperability between the mineral occurrence databases of British Columbia (MINFILE), Newfoundland (MODS), and the MineMatch system for describing global mineral deposits and mineral deposit models.

It has demonstrated this interoperability by comparing and similarity-ranking mineral deposits described on different provincial databases amongst each other, and with deposits and models from outside Canada.

Utilisation of the comparison and similarity ranking functions made possible by this project should make a substantial contribution to the understanding of, and classification of, the mineral deposits of British Columbia and Newfoundland, and to enhancements of the MINFILE and MODS database systems.

Standardized science languages were shown to be important in enabling semantic interoperability, and the value of current work by the Geological Survey of Canada in this regard was emphasised.

New computer programs and manual data processing methods were documented for extending semantic interoperability to other mineral occurrence and mineral deposit databases in Canada.

The XML schema produced as part of this project for the dissemination of mineral occurrence and mineral deposit data on the Internet embodies design elements not previously contemplated for mineral occurrence databases, but considered important to the goals of the CGKN.

A

GENERAL GUIDELINES FOR CONVERTING MINERAL OCCURRENCE DATABASE ENTRIES TO MINEMATCH DESCRIPTIONS

Introduction

There are two “end member” methods of migrating information in an already-existing Mineral Occurrences Database to MineMatch:

- (1) Programmatically, with a computer program reading information from the source database and (possibly after a number of steps) producing a collection of MineMatch descriptions
- (2) Manually, with a geologist reading the original database description, and entering it into MineMatch from the description entry screen.

The latter method is very time-consuming, but necessary in situations where crucial data in the source database is available only in a free text form. The former method is most effective when data in the source database was entered from a controlled vocabulary, and even then some processing steps may involve manual input, and may therefore also be quite time-consuming. Interestingly, though, the programmatic method can also be used effectively to speed up the translation of free-form descriptions, as illustrated in Appendix C for the translation of host-rocks in the MODS database.

The programmatic method involves three main processing steps:

- (1) De-normalising⁷ and de-coding⁸ the source database so that all its descriptors appear in one “transfer master-table” with multi-field, possibly multi-valued, “occurrence-specific” records. (MINFILE needed de-normalising and de-coding; MODS needed only decoding, and this only with respect to two attributes.)
- (2) Creating translation tables appropriate for each field in the transfer master-table which map each master-table descriptor to one or more MineMatch descriptors;
- (3) Running a batch process which uses the transfer master-table and translation tables as input, and which can produce either:

⁷ Conversion from 3rd Normal Form to 2nd or even 1st Normal Form.

⁸ To save disk space, many databases use short codes to represent longer values, which are then transformed to their long form for output purposes (eg: “038” for “Middle Proterozoic”).

- a. a directory of single MineMatch descriptions ready for deployment on the Internet, or
- b. a single MineMatch file which contains all the MineMatch descriptions, and which is for distribution by download independently of a MineMatch session for later offline use.

Creating a “Transfer Master-Table”: De-normalising and De-coding the Source Database

This is a process which will be unique for each database. It involves the movement of descriptive attributes into a single database field for later parsing, first by an analysis program, and later by a translation program. It can only be undertaken by someone experienced in describing mineral deposits, who has access to good quality documentation describing the database of interest. An example “Transfer Master-Table” is shown in Figure 18.

The process is best assessed by reading how it was tackled for the MINFILE database, as described in Appendix B of this document.

Creating Translation Tables: The “GeoConverter1” program

Translation tables are created for each field in the “Transfer Mater-Table” with the “GeoConverter1” program, a screenshot of which appears below.

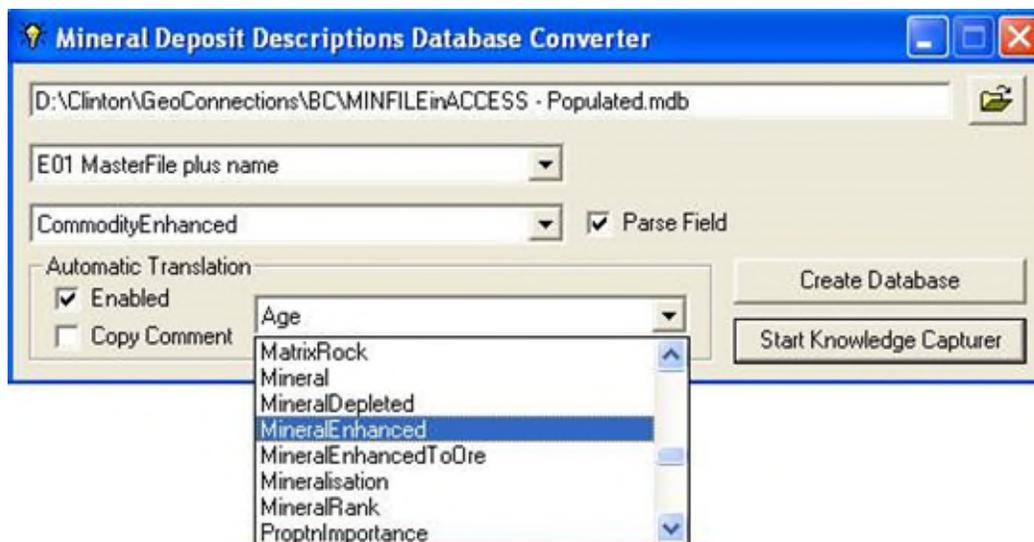


Figure 17
Screenshot of data input for GeoConverter1

The first line allows selection of the database holding the “transfer master-table”.

The second line allows for selection of the transfer master-table, a partial example of which is shown below:

MinfileNoName	CommodityEnhanced	DepositCharacter
082ENW048 Fap	Ag, Au, Cu, Pb, Zn	Shear, Stockwork, Vein
082ENW049 Sil	Cu, Mo, Zn	Disseminated, Podiform, Ve
082ENW050 James Lake	Cu, Wollastonite	Massive, Stratiform
082ENW051 Haynes Lake	U	Stratabound
082ENW052 Venus	U	Stratabound
082ENW053 Hydraulic Lake	U	Stratabound
082ENW054 Trepanier Gorge	Cu, Mo	Disseminated, Vein
082ENW055 Dam	Cu, Mo	Disseminated, Vein
082ENW056 Roy	Fe, Magnetite, Ti	Unknown
082ENW057 George Lake	Cu, Mo	Unknown
082ENW058 Kelowna	Clay	Unknown
082ENW059 Pan	Cu, Mo	Vein

Figure 18
Selected fields from an input table for GeoConverter1.

The third line allows for selection of the field in the transfer master-table for which a translation table is to be generated. If the field is to be parsed for multiple values separated by commas, then a tick should be placed in the “Parse Field” checkbox. Note that the example in Figure 18 above, “CommodityEnhanced”, has multiple values in many records.

If it is required that GeoConverter1 attempt to automatically match⁹ terms in the translation field to values of a MineMatch attribute, a tick should be inserted into the “Automatic Translation Enabled” checkbox. It will then become possible to indicate to the GeoConverter1 program which one of the attributes available in MineMatch (ie: in the MineMatch ontology) are to be searched for matches. The “MineralEnhanced” attribute has been selected in the screenshot, and an automatically matched entry in the GeoConverter1 output is shown in the figure below.

Instances	Description	Presence	Comment
Volcanic Ash			
Volcanic Glass			
W			
Wollastonite	Wollastonite	instance	
Y			
Zeolite			
Zn			
Zr			
	MineralEnhanced - Wollastonite	present	

Figure 19
Automatically matched MineMatch value in GeoConverter1 output.

If it is required that the string within which a matched value has been found be copied into the translation table comment field, then a tick should be placed in the “Copy Comment” checkbox. This

⁹ When GeoConverter1 is set to automatically match incoming terms to MineMatch terms, if it encounters a phrase, it parses the phrase from right to left to look for a matching term in MineMatch. Only single words are considered during the parsing and matching, and once a match is recognized, no further matches are sought.

string, which may contain valuable information not useable by MineMatch, is later carried across, by GeoConverter2, to the comment fields of any mineral occurrences with the identical describing string. A string with additional mineral information copied to the comment field is shown below:

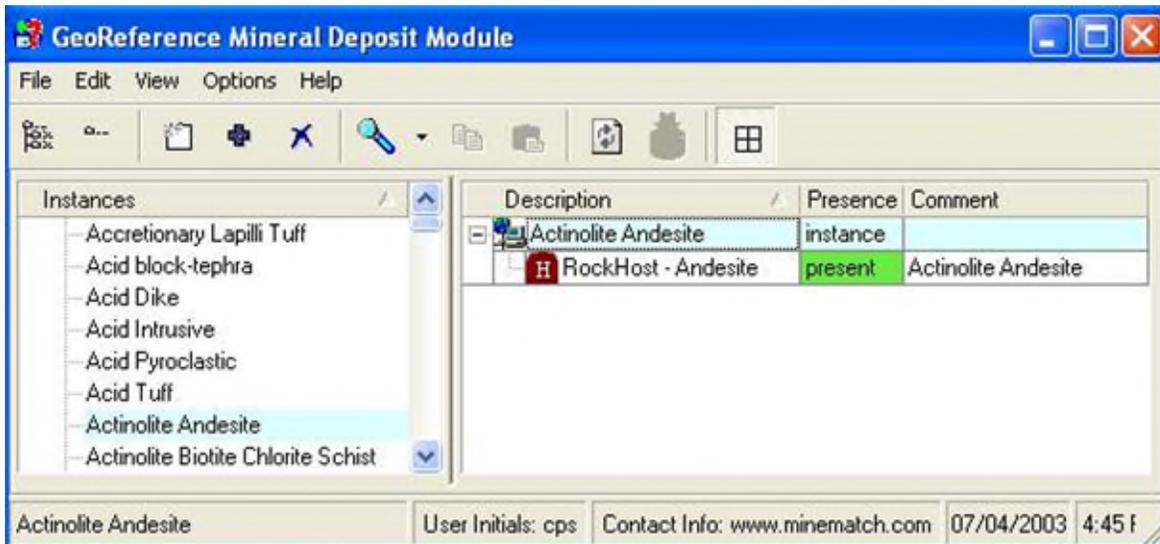


Figure 20
GeoConverter1 automatic transfer of descriptor strings to MineMatch value comment fields.

Terms which are not automatically translated can be manually translated to MineMatch terminology, sometimes requiring more than one term, or secondary qualifiers to more closely reflect the intention of the original data. This is illustrated in the examples below where the original data were coded (Figure 21, code appearing in the “Deposit Type” field), and the translation of “Deposit Type” code “112”, which required two MineMatch terms, as shown in Figure 22.

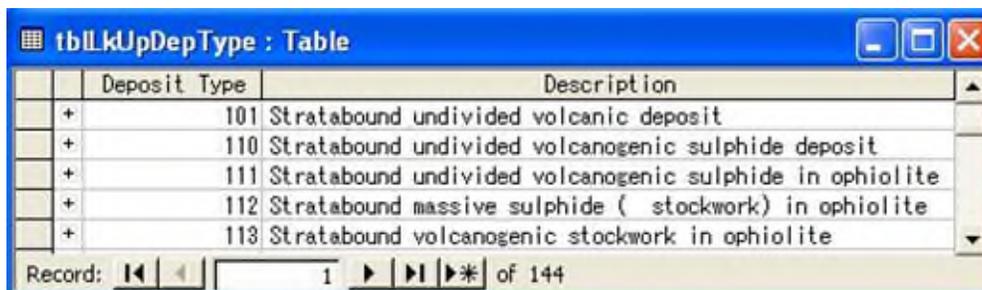


Figure 21
Coded source-table values with complex semantics requiring more than one MineMatch attribute for accurate translation (see Figure 22).

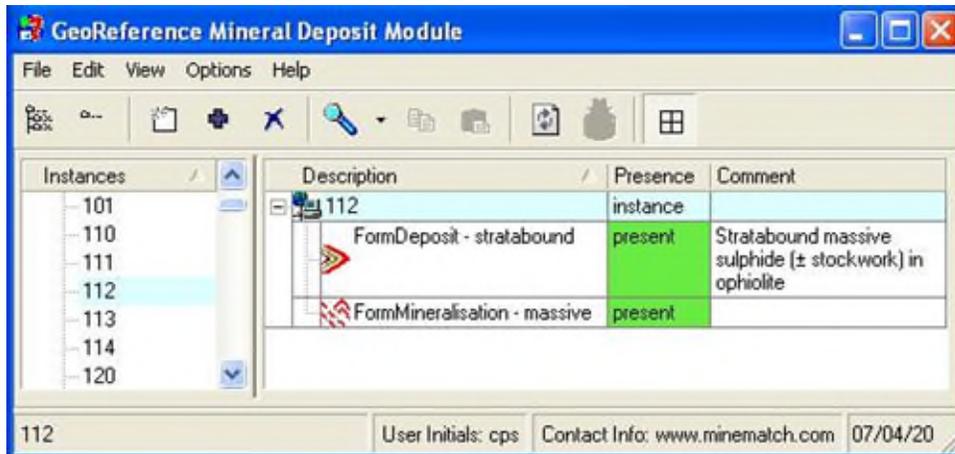


Figure 22
 Example, in GeoConverter1 output, of two manually entered MineMatch attributes required for translation of a single source database code shown in the previous figure.

Translating the Transfer Master-table

The transfer master-table is translated using the “GeoConverter2” program, as screenshot of which appears below.

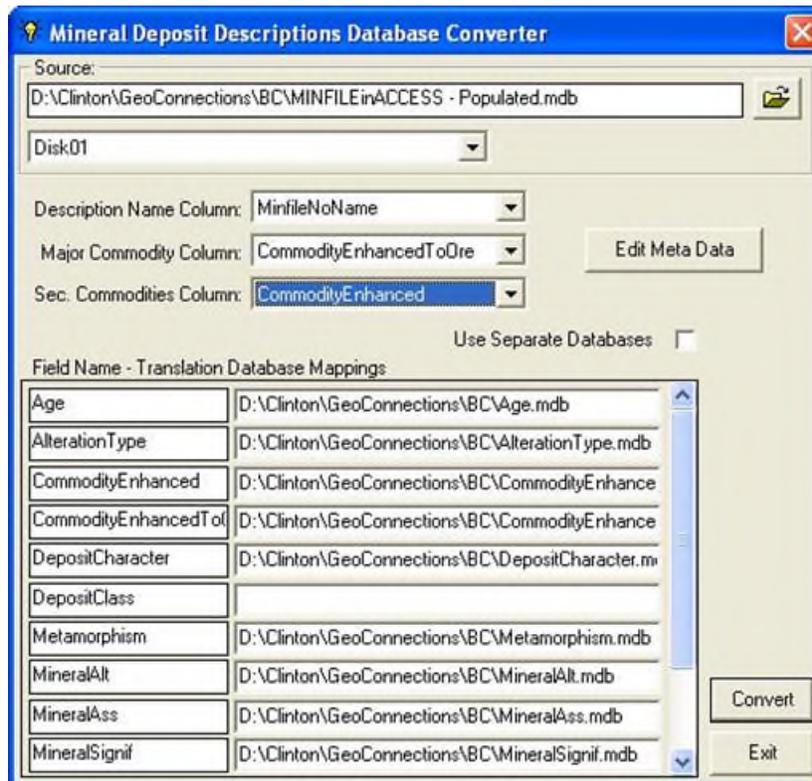


Figure 23
 The GeoConverter2 program’s main input form, immediately prior to the start of a translation run.

The first line provides for the selection of the database holding the translation master-table.

The second line allows for selection of the translation master-table. In the example shown above, a table holding a subset of the complete (MINFILE) dataset has been selected to prevent, for bandwidth reasons, too many descriptions from being visible on the Internet at one time. If output containing all 12000+ mineral occurrences together was desired, the original translation master-table would be selected here.

The third line allows selection of the field holding the mineral occurrence name, or primary identifier. As soon as this field is selected, the “Field Name –Translation Database Mappings” fields are auto-filled by the GeoConverter2 program. [The translation tables created by GeoConverter1 are required to be in the same directory as the database hosting the translation master-table, and are named by GeoConverter1 according to the name of the fields they translate.]

The fourth line allows selection of the field holding the primary commodities of the occurrence. These will appear on the left side (at the front) of the “Commodities” field in the table summarizing the descriptions in a MineMatch collection of descriptions.

The fifth line allows selection of the field holding the secondary commodities of the occurrence. These will appear after the primary commodities in the “Commodities” field in the table summarizing the descriptions in a MineMatch collection of descriptions.

Clicking on the “Edit MetaData” button will produce the following form, which is used to enter a complete reference to the source of the original database. Clicking on the “Generate” button will generate a unique reference identifier which is used as primary key linking each attribute/value pair in each description to its reference source¹⁰.

The screenshot shows a 'Meta Data' dialog box with the following fields and values:

- Source Info:
 - Source: MINFILE
 - Country (Region): Canada (B.C.)
- Reference:
 - Reference GUID: {85750A99-6426-469A-9F78-4AC0B8CA38993} (with a 'Generate' button)
 - Authors: Larry Jones et al
 - Title: BC MINFILE Database
 - Year: 2003
 - Publication Type: Electronic Source
 - Publication: (empty)
 - Volume: (empty)
 - Start Page: (empty)
 - End Page: (empty)
 - Editor: (empty)
 - URL: http://www.em.gov.bc.ca/Mining/Geosurv/Minfile/default.htm
 - Publisher: (empty)
 - ISBN / ISSN: (empty)
 - Notes: Any length of notes can be written here.

Figure 24
GeoConverter2 “metadata” input form, with example input data.

¹⁰ A modification is planned for this part of GeoCoverter2 which will record a different reference and link for each occurrence described. That unique reference will include in its URL field a URL pointing to the appropriate record in the Internet-enabled source database of the MineMatch description.

Deploying New MineMatch Descriptions on the Internet

Web Listings Architecture

Web-based MineMatch descriptions are stored in hierarchically arranged folders of any depth.

Each folder contains one “.lod” file which includes the following:

- (a) Pointers to sub-folders, if any exist
- (b) Summary information about descriptions in the collection, should a collection exist in the folder (some folders may not include any descriptions)
- (c) Optionally, a pointer to its parent folder

An example of the top level “.lod” file, which does not have an accompanying collection of descriptions, or a link to any parent folder, follows:

```
<MineMatch Instance Descriptions>
LODE<$$$>http://www.goli.ca/mmref/minocc/LODE/LODE\_Ins.lod
Data Metallogena<$$$>http://www.goli.ca/mmref/minocc/DM/DM\_Ins.lod
British Columbia<$$$>http://www.goli.ca/mmref/minocc/britishcolumbia/britishcolumbia\_Ins.lod
New Brunswick<$$$>http://www.goli.ca/mmref/minocc/newbrunswick/newbrunswick\_Ins.lod
Newfoundland<$$$>http://www.goli.ca/mmref/minocc/newfoundland/newfoundland\_Ins.lod
MineMatch Users<$$$>http://www.goli.ca/mmref/minocc/user/user\_Ins.lod
<Description List>
```

The “.../newfoundland_Ins.lod” referred to in the above example is shown below. It also has no associated collection of descriptions.

```
<MineMatch Instance Descriptions>
001K to 002D<$$$>http://www.goli.ca/mmref/minocc/newfoundland/001K to 002D/001K to 002D\_Ins.lod
002A to 012H<$$$>http://www.goli.ca/mmref/minocc/newfoundland/002A to 012H/002A to 012H\_Ins.lod
002E to 011P<$$$>http://www.goli.ca/mmref/minocc/newfoundland/002E to 011P/002E to 011P\_Ins.lod
012I to 013J<$$$>http://www.goli.ca/mmref/minocc/newfoundland/012I to 013J/012I to 013J\_Ins.lod
013K to 013M<$$$>http://www.goli.ca/mmref/minocc/newfoundland/013K to 013M/013K to 013M\_Ins.lod
013N to 024I<$$$>http://www.goli.ca/mmref/minocc/newfoundland/013N to 024I/013N to 024I\_Ins.lod
<Description List>
```

Finally the “001K to 002D” collection referred to above, which includes a collection of descriptions, is shown below:

```
<MineMatch Instance Descriptions>
Back To Previous Listing
(newfoundland)<$$$>http://www.goli.ca/mmref/minocc/newfoundland/newfoundland\_Ins.lod
<Description List>
001K/13/Pb 001 St. Mary's<$$$>http://www.goli.ca/mmref/minocc/newfoundland/001K to 002D/001K-13-Pb\_001\_St\_Mary's.zmd<$$$>tbl_0000000002<$$$>MODS<$$$>Pb, Cu, Zn<$$$>Canada(Newfoundland)<$$$><$$$><$$$><$$$>
001K/14/Cu 001 Chance Cove Brook<$$$>http://www.goli.ca/mmref/minocc/newfoundland/001K to 002D/001K-14-Cu\_001\_Chance\_Cove\_Brook.zmd<$$$>tbl_0000000002<$$$>MODS<$$$>Cu, Pb<$$$>Canada(Newfoundland)<$$$><$$$><$$$><$$$>
```

In the summary list of descriptions, the “<\$\$\$>” string is used as a field delimiter. The following six fields are available for instances:

1. The description name
2. The description’s URL
3. A system field reserved for future functionality. (Value not to be changed.)
4. Abbreviated indication of the sources of the description
5. Commodities in the instance of mineralization described.
6. Location of instance.
- 7,8,9. Fields available for recording best, second-best, and third-best matching deposit type to the described instance. These may, or may not be populated at the time of deployment.

The “GenerateWebListings” program is used to create the above files and directories, and is described below.

Using the “GenerateWebListings” Program

The deployment of the new MineMatch descriptions on the Internet is achieved with the “GenerateWebListings” program, a screenshot of which appears below.

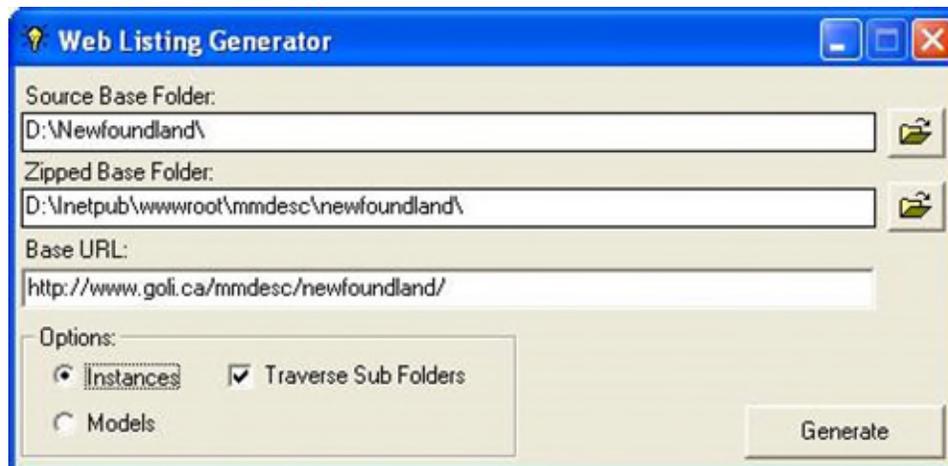


Figure 25
Screenshot of “GenerateWebListings” program

The first line allows selection of the folder in which either:

- (a) All MineMatch descriptions for deployment on the Internet as a single collection are to be found, or
- (b) A collection of sub-folders exist, each of which contains MineMatch descriptions for deployment on the Internet as a single collection.

The description collections will be collections of files output by the GeoConverter2 program. No other files should be in the specified directories. Attention should be given to how many descriptions should be lumped together in a single collection, as a summary list of descriptions in each collection is created,

and is downloaded when requested by MineMatch as a single file. Placing more than 1000 descriptions in a collection degrades performance on the Internet.

The second line allows selection of the folder into which the zipped copies of the MineMatch descriptions are to be placed. Depending on circumstances, this may be the ultimate destination folder on a web server. Or it may be a local folder which is later copied to a server.

The third line requires the input of the base part of the URL which will be the web address of each zipped description on the destination server. Concatenation of a description's file name to the end of this "base URL" provides the address of the description file. The full URL for each file is included in the summary list of descriptions mentioned above.

In the "Options" section, it should be indicated whether the descriptions for processing are models or instances, as the different kinds of descriptions have different fields in their summary lists. Also, it should be indicated whether the program is to process a single folder containing a collection of descriptions (no tick), or a folder containing a collection of folders, each containing a collection of descriptions (place tick in "Traverse Sub-Folders").

Clicking on the "Generate" button will zip all the descriptions, place them in the selected directories, and generate the necessary summary lists.

If the resulting collection(s) of zipped MineMatch descriptions are not generated directly onto the server, they then need to be copied into position.

Finally, it will be necessary to manually add a pointer to the highest level newly generated .lod file into an appropriate .lod file already existing on the server - following the example and format described in the previous section.

B

CONVERTING MINFILE DESCRIPTIONS TO MINEMATCH

Introduction

The MINFILE database is stored in dBase III tables. Consequently all those tables needed for the MineMatch translation were first imported into Microsoft Access 2002. In the description below, all table names refer to the Access versions of imported dBase III tables.

The design of the MINFILE database is shown in Figure 1 on page B-2.

A list of all the 12000+ mineral occurrences in MINFILE was created from the MINFILNO field in Table E01.

Since MINFILE allows up to 16 names for each occurrence, the following SQL query was written to extract the first-recorded (preferred) name in the R08 table for appending to the MINFILE number.

```
SELECT A.minfilno, B.NAME INTO [R08 Main Name]
      FROM [SELECT min(keyid) as id, minfilno
            from [r08 names new]
            group by minfilno]. AS A, [r08 names new] AS B
WHERE (((A.id)=[B].[keyid]));
```

This allowed occurrences to be identified by their preferred name and number in MineMatch.

De-normalising and De-coding the Source Database

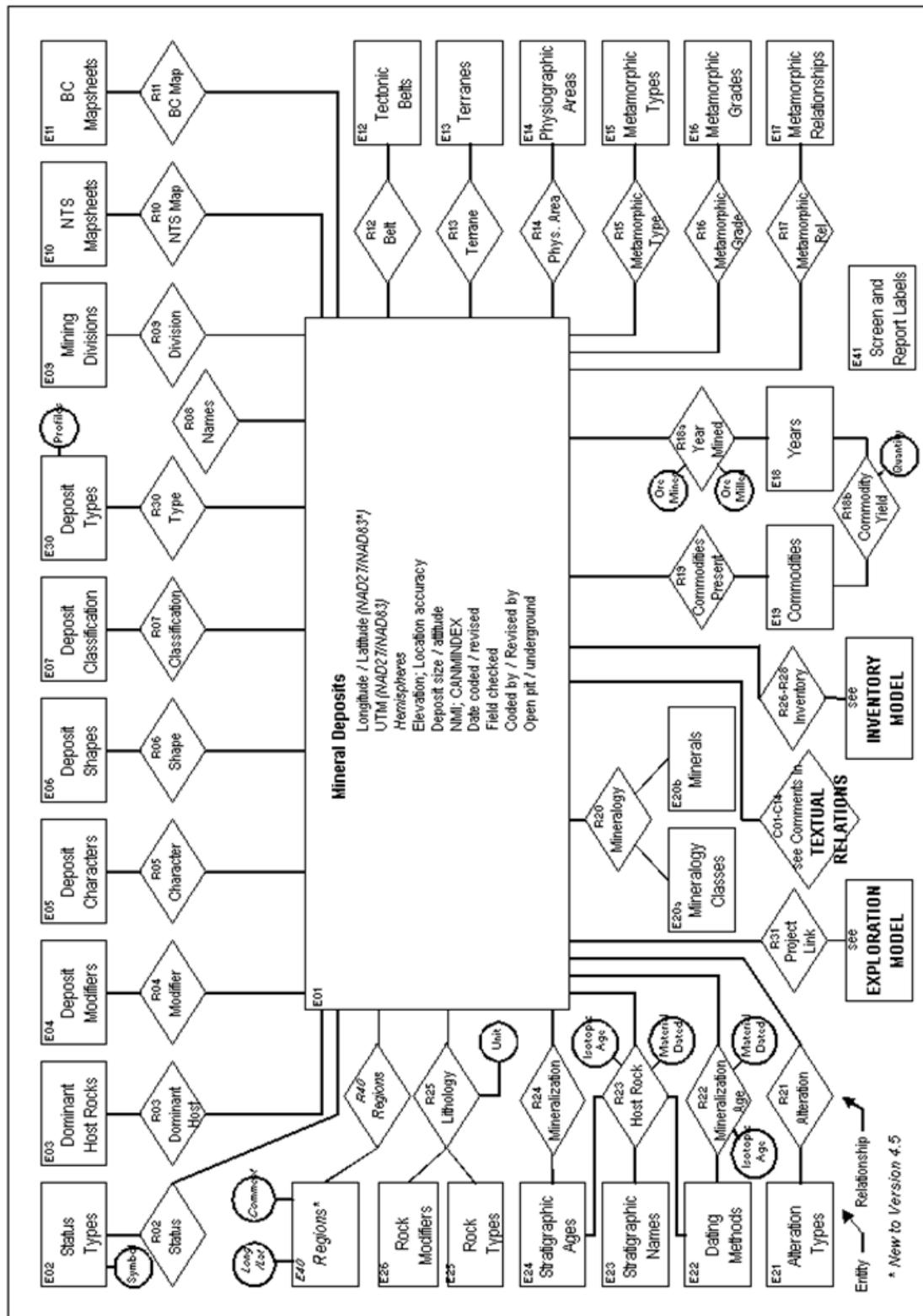
Actions carried out on MINFILE tables containing content of relevance to MineMatch are described on a “per table” or “per group of tables” basis below:

Table R20 (minerals)

Table R20 lists all minerals associated with each occurrence, and classifies them in regard to whether they are “Significant” – defined as “economic”, “Associated” – defined as “gangue”, or “Alteration”.

Table R20 uses codes from Table E20a for minerals, and from E20b for mineral categories.

MINFILE ENTITY/RELATIONSHIP DATA MODEL



An ER diagram showing the relationship between these three tables, and the translation master-table is shown in Figure 27 below, and extracts of the data they contain are shown in Figure 28.

The procedure “CombineMinerals” in the program Mod_Combine.bas¹¹ was written to transfer minerals from Table R20 to the appropriate rows and fields of Table E01 (with minerals from category “Significant” going into the “MineralSignif” field, from “Associated” into the “MineralAss” field, and from “Alteration” into the “MineralAlt” field). Figure 29 shows examples of the transferred data.

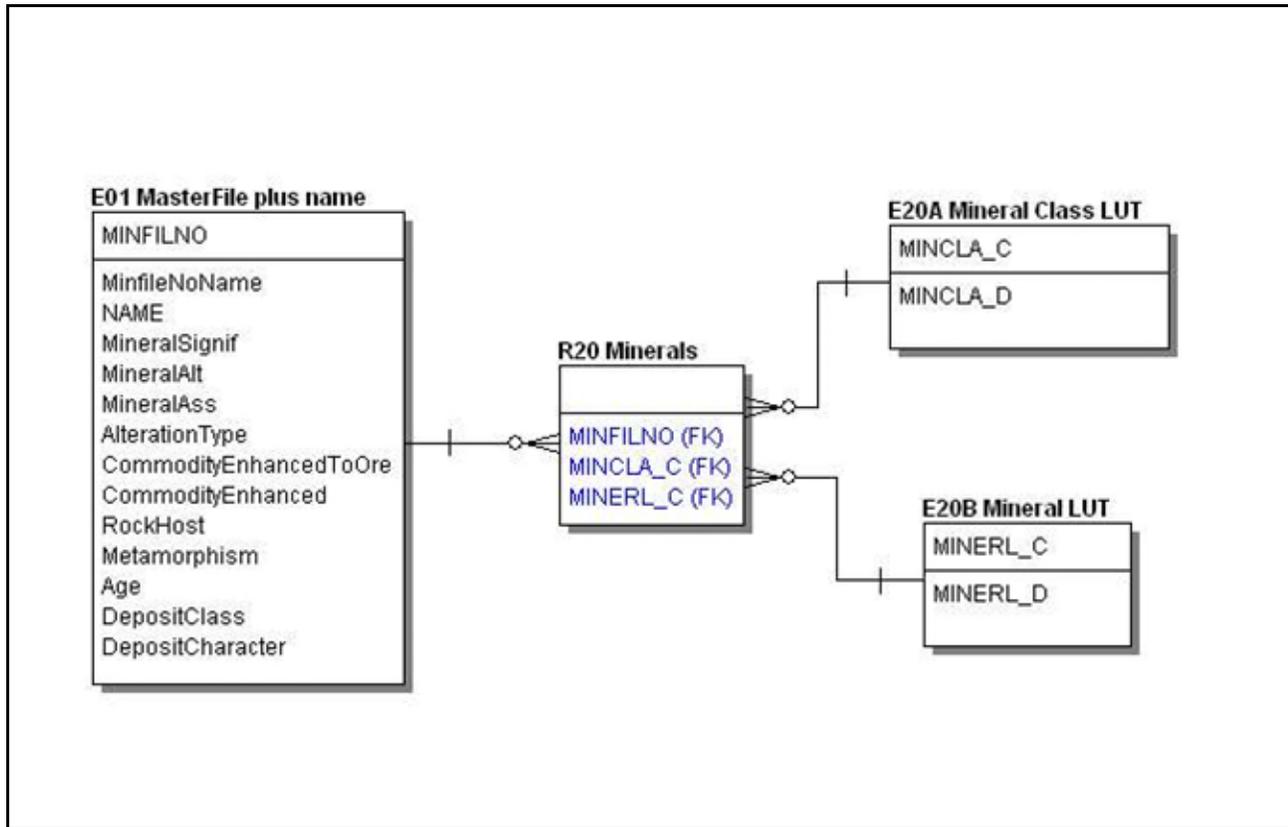


Figure 27
ER Diagram for minerals-related tables in MINFILE, and the translation master-table (E01)

¹¹ This program exists as a VBA module in the “MINFILEinACCESS – Populated.mdb” database on the CD accompanying this report.

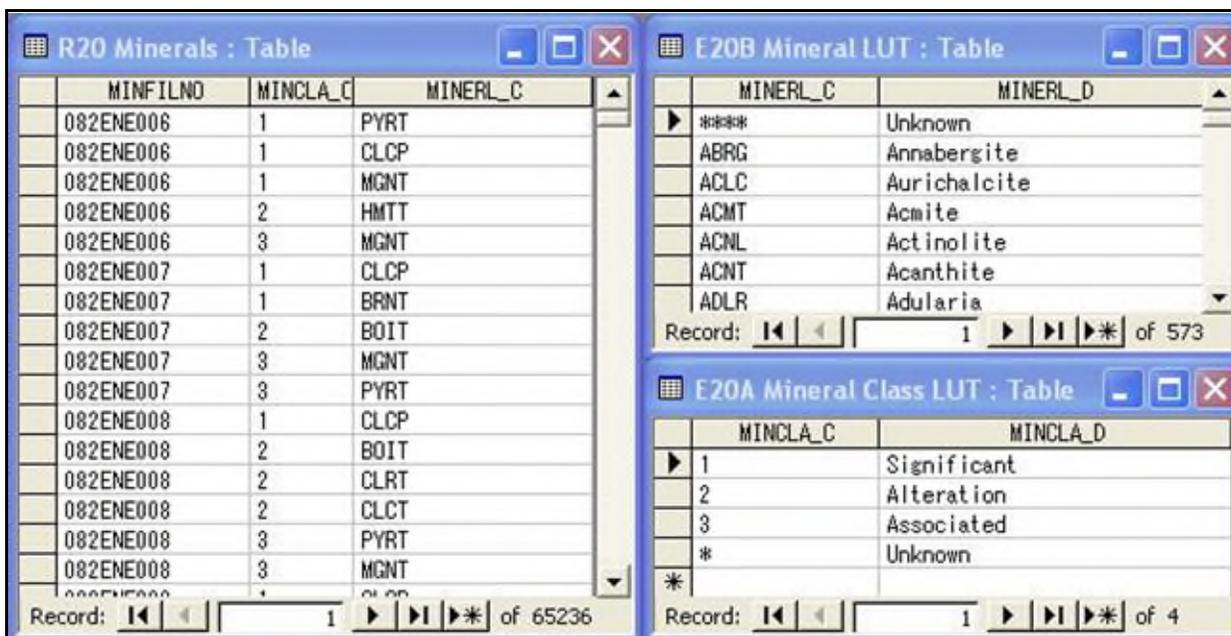


Figure 28 Data extracts from MINFILE Tables R20, E20a and E20b.

MINFILNO	MineralSignif	MineralAlt	MineralAss
082ENE001	Chalcopyrite, Galena, Magnetite	Azurite, Chlorite, Diopside	Calcite, Magnetite, Pyrite,
082ENE002	Chalcopyrite, Galena, Pyrite, Silica		Quartz
082ENE003	Argentite, Chalcopyrite, Galena	Garnet, Limonite, Silica	Pyrite, Quartz
082ENE004	Galena, Sphalerite		Calcite, Pyrite, Quartz, Sid
082ENE005	Chalcopyrite, Molybdenite, Pyrite	Chlorite, Epidote, Hematite	Calcite, Chlorite, Epidote,
082ENE006	Chalcopyrite, Magnetite, Pyrite	Hematite	Magnetite
082ENE007	Bornite, Chalcopyrite	Biotite	Magnetite, Pyrite
082ENE008	Chalcopyrite	Biotite, Calcite, Chlorite	Magnetite, Pyrite
082ENE009	Chalcopyrite, Pyrite	Silica	Pyrite, Quartz
082ENE010	Magnetite		Pyrite

Figure 29 Minerals data transferred into the translation master-table (E01).

Table R21 (alteration type)

Alteration type qualifiers were transferred from Table R21 into the “AlterationType” field of the translation master-table, using Table E21 to translate from the abbreviated codes. Figure 30 below shows examples of the transferred data.

E01 MasterFile plus name : Table				
MINFILNO	AlterationType	CommodityEnhancedToOre	CommodityEnhanced	
082ENE001	Oxidation, Skarn	Ag, Au, Pb, Zn	Cu	
082ENE002	Silicific'n		Ag, Au, Cu, Pb, Zn	
082ENE003	Oxidation, Silicific'n, Skarn	Ag, Au, Cu, Pb, Zn	Pd, Pt	
082ENE004			Pb, Zn	
082ENE005	Oxidation, Propylitic		Ag, Au, Cu, Mo, Pb, Pt, Zn	
082ENE006	Oxidation		Cu	
082ENE007	Biotite		Ag, Cu, Pd, Pt	
082ENE008	Biotite, Chloritic		Cu, Pd, Pt	
082ENE009	Oxidation, Silicific'n	Ag, Au, Cu	Pd, Pt	
082ENE010			Fe	
082ENE011	Oxidation, Skarn		Ag, Au, Cu, Mo, W, Zn	

Figure 30
Alteration Type and Commodity data transferred into the translation master-table (E01).

Table R19 (Commodities Present)

Commodities present at each occurrence are listed in Table R19, and annual production data for those that have been mined appear in Table R18b.

MineMatch distinguishes between commodities which are potentially economically recoverable, and those which are enhanced, but probably not to recoverable levels. For the MINFILE translation exercise, this distinction was made by translating all commodities with a yield recorded in Table 18b to the "...EnhancedToOre" status, while those without recorded yield were translated to the "...Enhanced" status. (**Note 1:** MineMatch distinguishes between "elements" and "minerals" rather than lumping them together as commodities. **Note 2:** Different policies may be appropriate for different situations: In some mineral occurrences, though no production has been realized, it may be valid to hypothesise on one or more of the enhanced commodities being at "enhanced-to-ore" levels, which would affect which other deposits or deposit models they may best resemble, and hence what information to look for in the course of further prospecting.)

In view of the decision above, the sub-routines "CombineCommodityEnhanced-ToOre" and "CombineCommodityEnhanced" in the Mod_Combine program¹² were written to populate the similarly-named fields in the translation master-table (example records in Figure 30 above).

Table R25 (Host Rock)

Table R25 lists all host rocks for each occurrence, together with their qualifiers

Table R25 uses codes from Table E25 for rocks, and from E26 for rock qualifiers.

An ER diagram showing the relationship between these three tables, and the translation master-table is shown in Figure 31 overleaf, and extracts of the data they contain are shown in Figure 32.

The sub-routine "CombineRockHost" in the Mod_Combine program¹² was written to transfer host rocks from Table R25 to the appropriate rows of Table E01. Figure 33 shows examples of the transferred data.

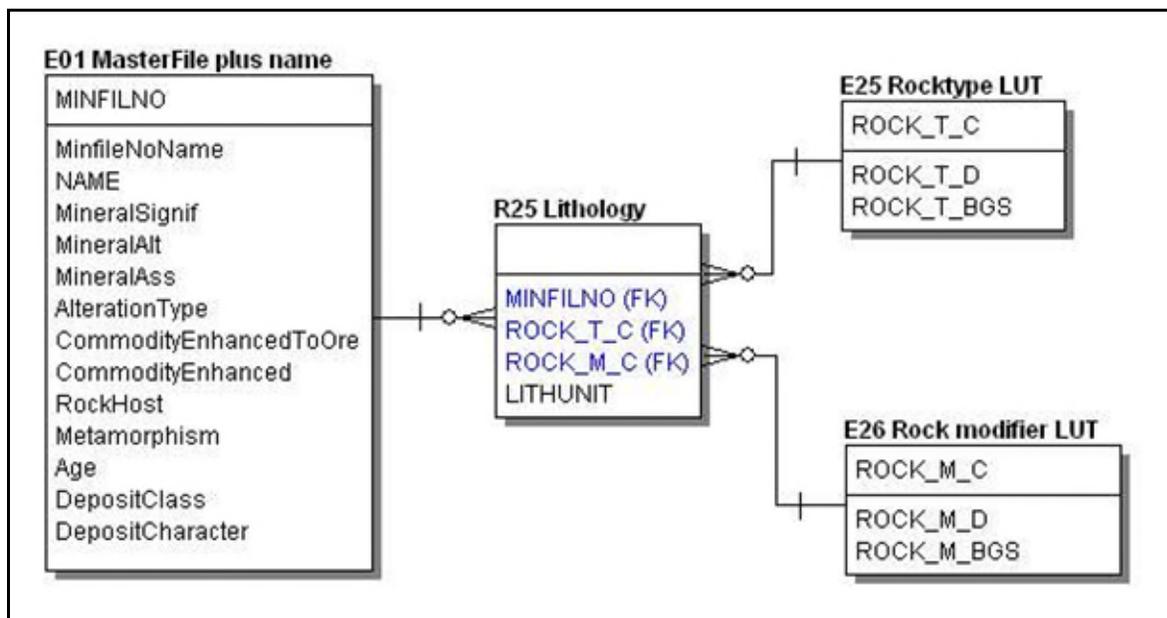


Figure 31
ER Diagram for Host Rock-related tables in MINFILE, showing fields where BGS terms equivalent to MINFILE terms were inserted (fields terminating in “BGS”).

R25 Lithology : Table			
MINFILNO	ROCK_T_C	ROCK_M_C	LITHUNIT
082ENE001	SKRN		082ENE00101
082ENE001	MRBL		082ENE00102
082ENE001	TUFF	ALRD	082ENE00103
082ENE001	GRDR		082ENE00104
082ENE001	PRPR	RYLT	082ENE00105
082ENE002	ANDT		082ENE00201
082ENE002	DCIT		082ENE00202
082ENE002	TUFF	SLCS	082ENE00203
082ENE002	QRZT		082ENE00204
082ENE002	CGLM	CLCS	082ENE00205
082ENE003	GRNS		082ENE00301
082ENE003	SYNT		082ENE00308
082ENE003	DCIT		082ENE00307
082ENE003	ANDT		082ENE00306
082ENE003	CGLM		082ENE00305
082ENE003	SLSN		082ENE00304
082ENE003	TUFF		082ENE00302
082ENE003	ARGL		082ENE00303
082ENE004	TUFF	PYRC	082ENE00401
082ENE004	CGLM	CLCS	082ENE00402

E25 Rocktype LUT : Table			
ROCK_T_C	ROCK_T_D	ROCK_T_BGS	changed
AGLM	Agglomerate	Agglomerate	<input type="checkbox"/>
AGTE	Agate	Agate	<input type="checkbox"/>
AKLC	Alkalic	Alkalic	<input type="checkbox"/>
ALBE	Albitite	granitic-rock	<input checked="" type="checkbox"/>
ALBR	Albertite	Albertite	<input type="checkbox"/>
ALNT	Alnoite	Alnoite	<input type="checkbox"/>
ALSK	Alaskite	granitic-rock	<input checked="" type="checkbox"/>
AMPH	Amphibolite	Amphibolite	<input type="checkbox"/>

E26 Rock modifier LUT : Table			
ROCK_M_C	ROCK_M_D	ROCK_M_BGS	changed
AFYU	Arfvedsonite	Arfvedsonite	<input type="checkbox"/>
AGLC	Argillaceous	siliciclastic argill:	<input checked="" type="checkbox"/>
AGLS	Anglesite	Anglesite	<input type="checkbox"/>
AGMC	Agglomeratic	agglomerate	<input checked="" type="checkbox"/>
AGRN	Aegirine	Aegirine	<input type="checkbox"/>
AGTE	Agate	Agate	<input type="checkbox"/>
AKLC	Alkalic	Alkalic	<input type="checkbox"/>

Figure 32
Data extracts from MINFILE Tables R25, E25 and E26.

MINFILNO	RockHost
082ENE001	Skarn, Marble, Altered Tuff, Granodiorite, Rhyolite Porphyry
082ENE002	Andesite, Dacite, Siliceous Tuff, Quartzite, Calcareous Conglomerate
082ENE003	metamafic-rock, Tuff, silicate-claystone, Siltstone, Conglomerate, Andesite, Dacite, Syenite
082ENE004	Pyritic Tuff, Calcareous Conglomerate, Granodiorite
082ENE005	Limy Quartzite, Granodiorite, Cherty Quartzite, silicate-claystone, Altered Tuff, metamafic-rock
082ENE006	Limy Quartzite, Granodiorite, Cherty Quartzite, silicate-claystone, Altered Tuff, metamafic-rock
082ENE007	Syenite, Pyroxenite, Monzonite, Monzodiorite, Pegmatite
082ENE008	Pyroxenite, Shonkinite, Monzonite, Syenite
082ENE009	Syenite, Trachyte Syenite, Andesite Dike, Pegmatite Syenite, Hornfels, Meta Sediment/Sedimentary,
082ENE010	Monzonite, Syenite, Pyroxenite
082ENE011	Skarn, Limestone, Siltstone, Granite, Andesite, Syenite Dike
082ENE012	Limestone, Quartzite
082ENE013	metamafic-rock, Cherty Quartzite
082ENE014	Granodiorite, Limestone, Andesite, Tuff
082ENE015	Conglomerate, Arkosic Sandstone, Siltstone, Carbonaceous Mudstone, Biotite Andesite, Trachyte, Ba
082ENE016	Quartz Monzonite

Figure 33
Host Rock data transferred into the translation master-table (E01).

The plethora of rock names is notable, and extends, for two of the records shown, off the field of view of the display window.

Table R16 (Metamorphism)

Metamorphism qualifiers were transferred to the translation master-table from tables R16, with look-up table E16, and R17, with look-up table E17, using the procedure “CombineMetamorphism” in the Mod_Combine program¹². Figure 34 below shows examples of the transferred data.

MINFILNO	Metamorphism
082ESW020	Pre-mineralization Amphibolite, Pre-mineralization Greenschist
082ESW021	Pre-mineralization Greenschist
082ESW022	Pre-mineralization Greenschist
082ESW023	Greenschist
082ESW024	Greenschist
082ESW025	Greenschist
082ESW026	Greenschist
082ESW027	Greenschist, Hornfels

Figure 34
Metamorphism data transferred into the translation master-table (E01).

Table R24 (Age of Mineralisation)

For the purposes of this exercise, the simplifying assumption was made that the age of the mineralization is approximately the same as the age of the host lithology. Table R24 was simply

joined with Table E24 to derive the un-coded time-period names, and these were transferred to the Age field in the translation master-table, as illustrated in Figure 35 below.

Table R05 (Deposit Character)

Entries in Table R05 were concatenated into the “DepositCharacter” field in the translation master-table, using the full renditions of the qualifiers as obtained from Table E05. Examples of these are shown in Figure 35 below.

MINFILNO	Age	DepositClass	DepositCharacter
082LSW112	Triassic	Industrial Min., Metamorphic	Layered, Stratiform
082LSW113	Eocene	Industrial Min., Magmatic	Massive
082LSW114	Eocene	Exhalative, Industrial Min.	Stratiform
082LSW115	Mesozoic-Cenozoic	Epigenetic, Hydrothermal, I	Stockwork, Vein
082LSW116	Mesozoic-Cenozoic	Epigenetic, Hydrothermal	Vein
082LSW117	Mesozoic-Cenozoic	Epigenetic, Hydrothermal	Vein
082LSW118	Mesozoic-Cenozoic	Epigenetic, Hydrothermal	Vein
082LSW119	Mesozoic-Cenozoic	Epigenetic, Hydrothermal	Stockwork
082LSW120	Mesozoic-Cenozoic	Unknown	Concordant, Disseminated, Stratabound
082LSW121	Eocene	Industrial Min., Magmatic	Massive
082LSW122	Tertiary	Epigenetic, Industrial Min.	Disseminated, Stratabound
082LSW123	Mesozoic-Cenozoic	Epigenetic, Hydrothermal	Vein
082LSW124	Mesozoic-Cenozoic	Epigenetic, Hydrothermal	Vein
082LSW125	Eocene	Epigenetic, Industrial Min.	Disseminated, Podiform, Stratabound, Vein
082LSW126	Mesozoic-Cenozoic	Epigenetic, Hydrothermal	Vein
082LSW127	Tertiary	Porphyry	Disseminated
082LSW128	Jurassic	Porphyry	Disseminated, Stockwork
082LSW129	Tertiary	Epigenetic, Industrial Min.	Stratabound
082LSW130	Eocene	Epithermal	Disseminated

Figure 35
Deposit Character and Host Rock Age data transferred into the translation master-table (E01).
Also shown is “deposit class” information available in MINFILE, but not considered relevant for transfer to MineMatch.

Creating Translation Tables

Once all information describing a particular attribute in MINFILE is available in a single column of the translation master-table, it is possible to parse all records of the field for all unique values, and then to map these to their corresponding values in MineMatch.

The “GeoConverter1” program was developed for this purpose, and it is described in Appendix A.

The translation files listed below were generated using GeoConverter1 for the later translation of the MINFILE translation master-table into MineMatch. All are available for review on the CD which accompanies this report.

Conversion Table	Comments
Age.mdb	Many exact matches of terms. Qualifiers (early<> lower) needed translation, as did layout of combined periods (eg: “Miocene-Pliocene”)
AlterationType.mdb	A number of terms added to the alteration terms used by MineMatch.
CommodityEnhanced.mdb	Commodities not addressed by MineMatch were ignored here (eg: coal, industrial minerals). Translation was to “ElementEnhanced” for elements. (Minerals were ignored in order to avoid duplication by entries from the “MineralSignif” field.
CommodityEnhancedToOre.mdb	Commodities not addressed by MineMatch were ignored here (eg: coal, industrial minerals). Translation was to “ElementEnhancedToOre” for elements and “MineralEnhancedToOre” for minerals.
DepositCharacter.mdb	Attribute values were translated to accompany the attribute considered most appropriate (eg: “podiform” to FormMineralisationHost (pods); “massive” to FormMineralisation(massive)).
Metamorphism.mdb	Traditional “greenschist”, “amphibolite”, etc terms translated to the terms used by MineMatch, which are the terms recommended by the Geological Society of London (“low grade”, “medium grade”, etc)
MineralAlt.mdb	Many MINFILE minerals translated to preferred synonyms available in MineMatch and recommended in Dana II (eg: “aegrine” in MM for “acmite” in MFILE; stibarsen in MM for “allemonite” in MFILE; etc)
MineralAss.mdb	As above.
MineralSignif.mdb	As above.
MINERL_D.mdb	The “synonyms” translation described for the three fields above was in fact carried out by using Geoconverter1 on the MINERAL_D field of MINFILE Table E20b, with its auto-convert attribute set to “Mineral”. A copy of this file was then used to create each of MineralAlt.mdb and MineralAss.mdb.
MINERLenhanced_D.mdb	Created with a program which changed the attribute of the MINERL_D translation table from “Mineral” to “MineralEnhanced”. Then a copy of this table was used to create the MineralSignif.mdb table shown above.
RockHost.mdb	A number of MINFILE rock types were re-named in the Host Rock field to enable GeoConverter1 to automatically match them with MineMatch rock names (eg: diabase with dolerite; dolomite with dolostone; etc).

Table 7-1
MINFILE Translation Tables produced with GeoConverter1.

Translating the Transfer Master-table

Using the translation tables described in the section above, the GeoConverter2 program was used to translate the information in the translation master-table into MineMatch descriptions.

GeoConverter2 is described in Appendix A.

Translations were batched into groups of around 1000 descriptions each to facilitate Internet interaction with the descriptions on a telephone line.

A single batch of all 12000+ descriptions was also created for independent download from the Internet.

Deploying the MINFILE Descriptions on the Internet

The batched MINFILE descriptions were deployed on the Internet using the program “GenerateWebListing”, which is described in Appendix 1.

C

CONVERTING MODS DESCRIPTIONS TO MINEMATCH

Introduction

MODS was made available to GeoReference Online Ltd as an Access 2002 database, and its design is shown in Figure 36 overleaf.

A list of the 4000+ mineral occurrences in the MODS database was created from the NMINO field in the tblDescriptors table, to which was appended the primary name of the occurrence from the DepName field of the tblIds table. This allowed occurrences to be named by their preferred name and number in MineMatch.

The list was called “WebMODS”, and retained the following fields from tblDescriptors:

Comname	Commods	OreMin	WRAlt	AltType
AgeMin	DepType			

De-normalising and De-coding the Source Database

Unlike the MINFILE database described in the previous section, the MODS database is generally not normalized, and multiple attribute values appear within a field, separated by commas. As a result, no de-normalising was necessary, and most decoding could be undertaken as part of the next “translation” step.

Because of special use made by MineMatch of element symbols when describing the commodities present in a mineral deposit, however, it proved prudent to manually (with a “Find & Replace” utility) change all full words describing elemental commodities to the element symbols. This produced a table called “WebMODSwithElements”.

Creating Translation Tables

With an analysis of the (sometimes) comma-delimited, non-normalised attribute values in the MODS database fields, it is possible to map values to MineMatch attributes and values.

Values from one field may map to different attributes as well as different values in MineMatch. For example, while MODS semantics speak of “commodities”, into which both elements and minerals are grouped, MineMatch groups elements separately from minerals. Further, MineMatch stores lead as “Pb”, while MODS stores it as “Lead”.

Hence the MODS content describing a mineral occurrence with “Major Commodity – Lead” translates to a MineMatch representation of “ElementEnhancedToOre – Pb”, where “Major Commodity” and “ElementEnhancedToOre” are attribute names in MODS and MineMatch respectively.

The GeoConverter1 program (Appendix A) was developed to parse all records of each MODS field relevant to MineMatch for all unique values, and then to map these to their corresponding values in MineMatch. The mapping is semi-automatic, with GeoConverter1 attempting to match terminology of the incoming database to terms in one “attribute domain” of the user’s choice. Values that are left unmatched after the auto-matching phase of GeoConverter1 have to be manually mapped to appropriate MineMatch values.

The translation tables listed overleaf in Table 7-2 were generated in this “two-pass” fashion, for the later translation of the “WebMODSwithElements” table to MineMatch. All are available for review on the CD which accompanies this report.

Translating the Transfer Master-table

Using the translation tables described in the section above, the GeoConverter2 program was used to translate the information in the “WebMODSwithElements” table into MineMatch descriptions. GeoConverter2 is described in Appendix A.

Translations were batched into groups of around 1000 descriptions each to facilitate Internet interaction with the descriptions on a telephone line.

A single batch of all 4600+ descriptions was also created for independent download from the Internet.

Deploying the MINFILE Descriptions on the Internet

The batched MINFILE descriptions were deployed on the Internet using the program “GenerateWebListing”, which is described in Appendix A.

Conversion Table	Comments
AgeMin.mdb	Numeric codes translated using tblLkUpAgecode (see Figure X)
AltType.mdb	No significant problems with translation of terms in tblLkUpAltType to MineMatch “AlterationType” values.
ComMods.mdb	Commodities not addressed by MineMatch were ignored here (eg: gas, industrial minerals). Translation was to “ElementEnhanced” for elements, and “MineralEnhanced” for minerals, although recognizing that some of these could qualify for “...EnhancedToOre” attributes. However this requires manual input, and can be undertaken in the future.
Comname.mdb	Commodities not addressed by MineMatch were ignored here (eg: gas, industrial minerals). Translation was to “ElementEnhancedToOre” for elements and “MineralEnhancedToOre” for minerals.
DepType.mdb	Entries were translated to one or more attribute/value pairs considered most appropriate (eg: “Undivided deposit related to intrusive magmatic or magmatic - hydrothermal processes” to “FormDepositRelated – intrusive”).
OreMin.mdb	Translated to “MineralEnhancedToOre”.
Rocks.mdb	Many rock names used in MODS descriptions were first manually translated (using “Find & Replace”) to BGS-preferred synonyms (eg: “shale” in MODS for “metamudstone” in MineMatch (BGS Rock Classification System), and plurals were changed to the singular used in MineMatch/BGS RCS. Then reliance was placed on GeoConverter1 to match as many rock names as possible with the MineMatch/BGS terms. Time constraints did not allow additional manual translations, which would enhance the collection of MODS-MineMatch descriptions, and which is recommended for action in the future.
WRAlt.mdb	Translated to “MineralEnhanced”.

Table 7-2
MODS Translation Tables produced with GeoConverter1.

D

PAMPHLET DESCRIBING MINEMATCH

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- Realize Value in GIS Data*

Benefits

- **TARGET GENERATION** - Rapidly evaluate mineral occurrence data against target models.
- **FAST DEPOSIT & MODEL COMPARISONS** - Quick deposit-type classification. Quick similarity-rankings against other deposits or prospects.
- **PROPERTY PROMOTION** - Make properties easy to evaluate by providing MineMatch descriptions.
- **TRAINING** - MineMatch is a superb educational tool for junior and experienced geologists alike.
- **COLLABORATION** - Record and annotate knowledge in an easily shareable form.



MineMatch Online will be launched as a "pay-per-use" web service on 1 April, 2004

MineMatch is a unique Internet or desktop-based system for describing and intelligently comparing mineral deposits and mineral deposit models - as well as exploration prospects in any stage of development.

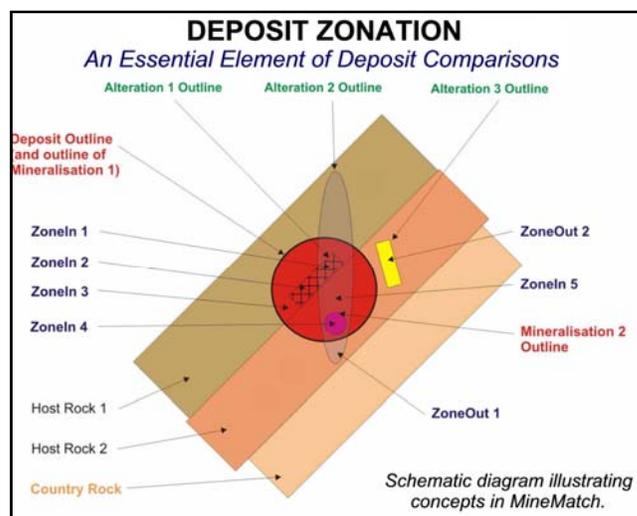
MineMatch can automatically produce deposit or prospect similarity rankings¹, which take many days of costly work by an expert geologist.

MineMatch assists exploration geologists to integrate the complex data arising from their projects with the overwhelming volume of information available on other deposits and models in the world, which may be crucial to their projects.

* [Online Case Study:
WWW.ROCKSTORICHESBC.COM](http://WWW.ROCKSTORICHESBC.COM)

Efficiency Example		
Task	MineMatch	Geologist
Describe deposit in MineMatch	-	1 to 4 hrs
Compare to 100 models	1 hour	days
Compare to 200 deposits	1 hour	days
Compare to 1000 occurrences	1 hour	days
Provide advice based on similarities reported by MineMatch	Immediate	Variable

MineMatch uses modern techniques of knowledge representation and logic programming, enabling it to take into account the zonation of mineral deposits and the complexity of geological terminology - issues ignored by most deposit databases, but used in MineMatch to enhance similarity rankings and audit trails.



¹ All similarity rankings are subjective. **MineMatch** rankings are well-reasoned and auditable. They are based on logic, fuzzy logic, and carefully selected and defined technical terminology. Better user descriptions result in more accurate rankings.



>>> NEW <<<

MineMatch Online will be launched as a "pay-per-use" web service on 1 April, 2004

Fast Intelligent Geological Analysis of Mineral Deposits and Exploration Prospects

MineMatch Features

- **Automatic Comparisons of Descriptions** World First
Comparisons of any two descriptions (models or deposits, with zones) in a colour-coded table highlighting matching, conflicting and neutral attributes.
- **Automatic Similarity Rankings of Multiple Comparisons** World First
Similarity rankings for multiple comparisons (best-to-worst match ordering, including zonal considerations).
- **All Deposit-Types in One Knowledge Base** World First
All deposit-types, including their zones, in one system, facilitating the evaluation of hybrid deposits, and poorly understood prospects.
- **Internationally-Accredited Terminology Dictionaries** World First
Incorporated into the Deposit/Model Description Module.
- **Features Absent from Deposits can be Recorded** World First
Specify which features are NOT present in a deposit.
- **Expected Frequencies of Features in Models** World First
Specify whether zone-specific model features are expected: Always/Usually/Sometimes/Rarely/Never.
- **Choice of Output Formats**
Descriptions, Comparison Tables, and Similarity Rankings can all be output to Excel², HTML or a printer.
- **Import / Export Facility**
Import or export descriptions for distribution between different parties.
- **Explanation Facility** World First
System can explain why attribute values are recognised as matching (eg: "tennantite" with "sulfo-salt").
- **Quality Control and References - Auditability**
MineMatch can record different references for each fact in a description, as well as who entered each fact.
- **Comprehensive System Documentation**
"HELP" documentation includes assistance on how to describe deposits so that they can be effectively compared.
- **Web Support** **Version 3 is INTERNET enabled**
MineMatch is supported by a comprehensive web site from which additional model, mine and prospect descriptions can be downloaded on an annual subscription basis. **Immediate online access to latest descriptions**
- **Sponsor of Data Metallogenica**
Data Metallogenica (www.datametallogenica.com) is an unparalleled reference collection of Internet-accessible photographs of +60000 samples from more than 4000 mineral deposits across the world. GeoReference Online Ltd is a sponsor of DM. **MineMatch** is an ideal repository for descriptions of deposits & mineral assemblages photographed on DM.

² Excel needs to be on the system for output to Excel.
Excel is a registered trademark of Microsoft Corporation.

MineMatch Descriptions

Deposit Type Descriptions (Models)

MineMatch is delivered with 91 **USGS** deposit model descriptions (Cox and Singer, 1986) 15 **British Columbia Geological Survey** models, and 20 **Geological Survey of Canada** models, to which any new models may be added.

Deposit Descriptions

MineMatch is delivered with the following deposit descriptions:

- 70 of the largest mineral deposits in Europe, from the GEODE project;
 - 25 mines in the www.DataMetallogenica.com collection;
 - 22 mines from China, Peru, British Columbia, Newfoundland and South Africa entered by private & government users of MineMatch.
- In June 2004 GeoScience Australia's descriptions of more than 800 mines in Australia will become available in MineMatch format.

Mineral Occurrence Descriptions

1768 mineral occurrence descriptions from the Andes regions of Argentina, Bolivia, Chile and Peru are now available in MineMatch. All British Columbia's, Newfoundland's and New Brunswick's mineral occurrences are also available in MineMatch (approximately 20,000 mineral occurrences).

Services

GeoReference Online Ltd (GOL) provides the following MineMatch-related services:

- **INPUT OF MINEMATCH DESCRIPTIONS:** GOL can quickly enter descriptions required in **MineMatch**.
- **MINEMATCH WORKSHOPS** - One, two or three day workshops on describing deposits and deposit models using recognised standard terminologies.
- **LARGE-SCALE DATABASE CONVERSIONS** : GOL can convert existing mineral deposit and mineral occurrence databases into MineMatch. This may include translation to and from English.
- **INTERNET DEPLOYMENT:** GOL can deploy national MineMatch databases on the Internet.
- **REGIONAL TO NATIONAL SCALE GIS STUDIES:** GOL adds value to large-scale GIS data sets by integrating them with the knowledge of mineral deposits and deposit models built into MineMatch. Visit our website for examples: www.minematch.com

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For more information about **MineMatch**, please visit our web site

www.minematch.com

E

EXAMPLE OUTPUT FROM PREVIOUSLY RECOMMENDED XML SCHEMA FOR MINERAL OCCURRENCE DESCRIPTIONS

Page 1 of 2

Property List for Mineral Occurrence
on.MDI31C05NE00018

▼ **Identification**

Province	Ontario
Status	Discretionary Occurrence
Mining Division	Larder Lake
Regional Geologist District	Southeastern Ontario
Township	Marmora
Lot	6
Concession	8
Section	W
Legal Description	E part of Lot 6.
Name List	
Name	Rank
Ackerman	1
Campbell-Blomfield	2

▼ **Location**

Location	Long: -77.61310 Lat: 44.49970
Object Located	Overburden drill hole
Access Description	unknown
Location Certainty	unknown
NTSMapSheet	031C05NE(Primary)031C12SE(Secondary)

▼ **Mineralogy**

Ore Mineral List	
Name	Rank
Arsenopyrite	5
Calcite	10
Fluorite	15
Gold	20
Magnetite	25
Pyrite	30
Alteration Mineral List	
Name	Rank
Siderite	1
Quartz	2
Hematite	5
Pyrite	8
Alteration Type List	
Name	Rank

<http://www.galdosinc.com/geoscience/results/canadaDataSample-Props/MOon.MDI31C05NE00018.html> 1/22/2003

Sericitic	-
Silicification	-
Hematization	-
Pyritization	-

▼ **Geology**

Geological Unit	Superior
Deposit Type	inapplicable
Deposit Class	unknown
Deposit Character	unknown
Metamorphic Grade	Greenschist
GeoChronological Age	Neoproterozoic
Absolute Age	2700
Comment	+/- 3 MA

▼ **Host Rock**

Host Rock		
Dominant Rock Type		inapplicable
Group	Garnet-Toombs	
Lithology List		
Rock Type		Modifier
Intermediate Intrusive		SYENITE
VEIN		Syenite

- ▶ [Inventory](#)
- ▶ [Production](#)
- ▶ [Work History](#)
- ▶ [Exploration](#)

Please select one of the sections to open it by clicking on the title or arrow