# MINERAL POTENTIAL ASSESSMENT PROJECTS - AN UPDATE

By Ward E. Kilby

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*KEYWORDS:* Mineral assessment, geology compilation, expert estimation, world wide web.

## INTRODUCTION

During 1995, the third year of the Mineral Potential Project, the mineral assessment methodology was standardized, geological compilations were completed on schedule and expert estimations were completed on two new regions and more structured assessments completed on two other regions. In addition, the information collected during the analyses and the results of the analyses were made available on the Internet.

## 1995 PROGRESS

### *NORTHWEST BRITISH COLUMBIA GEOLOGICAL COMPILATION*

Geological compilation of the northwest region was started in April of 1995. This 155 000 square kilometre region is being compiled by seven Geological Survey Branch geologists led by Mitch Mihalynuk, with significant input from Geological Survey of Canada geologists (Figure 1). The compilation is scheduled for completion and release as an open file in January of 1996. The associated mineral assessment will be completed by April 1996.

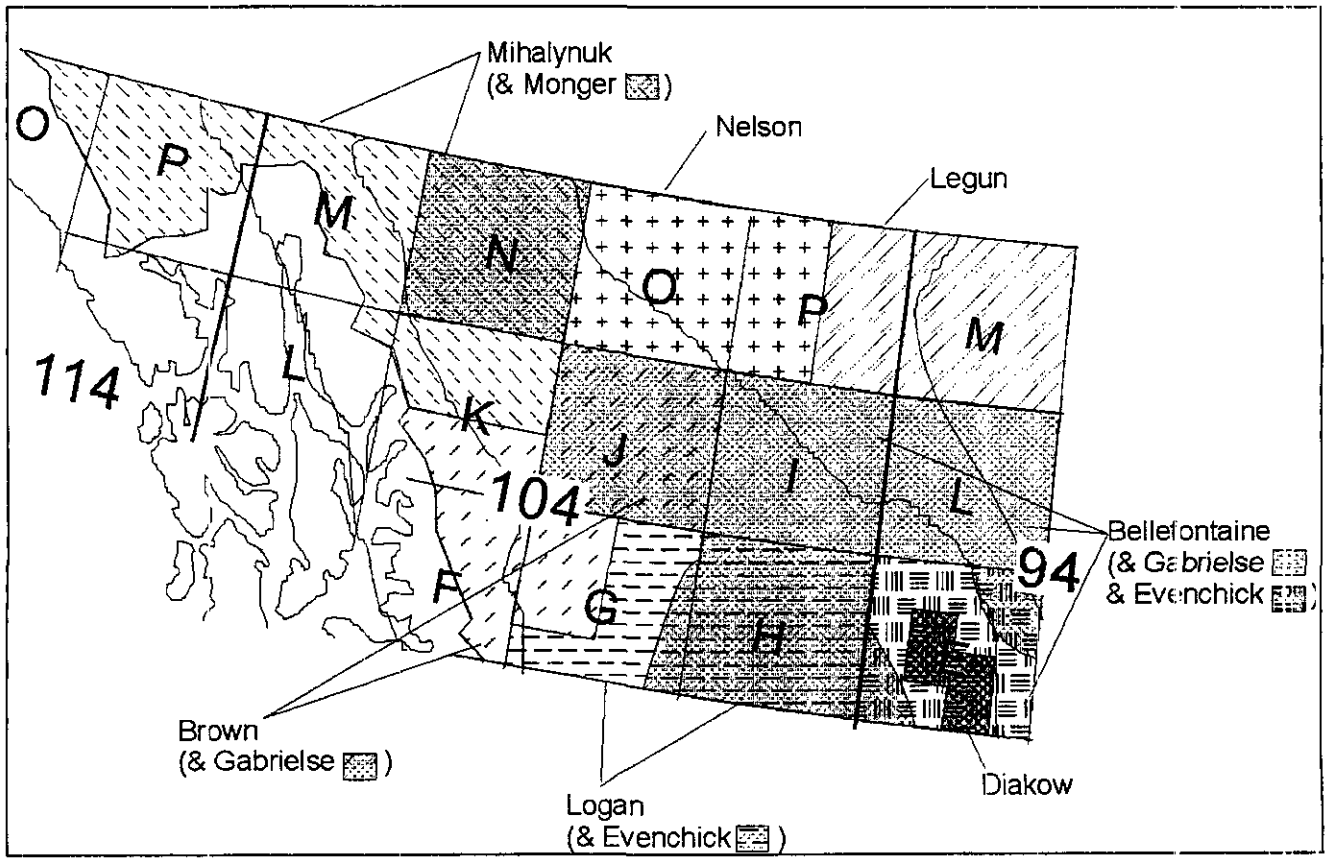


Figure 1. Northwest British Columbia Mineral Assessment Region, showing the geologist responsible for compilation in various sections of the project

## *NORTHEAST BRITISH COLUMBIA MINERAL ASSESSMENT*

During the last year, the geology for the northeast region was completed and released as two digital open files (McIntyre *et al.*, 1995; Bellefontaine *et al.*, 1995). In March 1995 an estimation workshop was held to obtain estimates of the potential for future mineral discoveries in this region. At the workshop, 24 estimators evaluated the 136 tracts in the region for 70 possible deposit types, generating 4050 individual estimates.

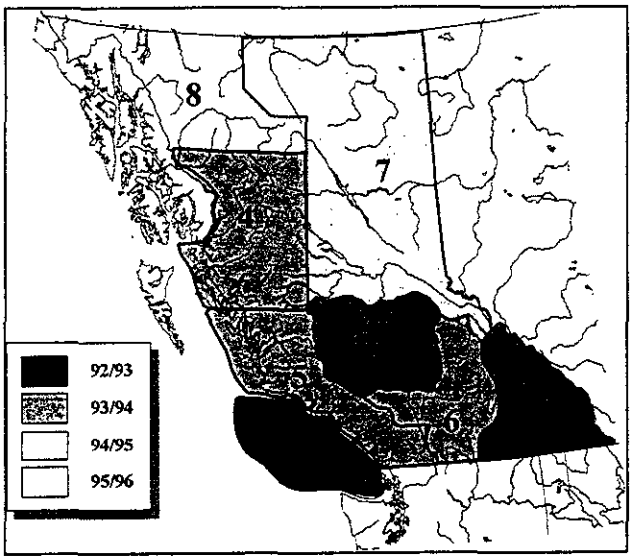


Figure 2. Locations of the various study areas. Mineral potential assessment regions; 1-Vancouver Island, 2- Cariboo-Chilcotin, 3- Kootenays, 4- Skeena-Nass, 5- Mid-Coast, 6- Thompson-Okanagan, 7- Northeast BC and 8- Northwest BC. The Muskwa - Kechika area occupies the northwestern part of the northeast region.

Estimates of future mineral discoveries and the final mineral assessment were made for the whole Northeast British Columbia Region and an extension into the Northwest British Columbia Region. This extension was added to address the urgent need for an analysis of the Muskwa-Kechika area (B.C. Ministry of Energy, Mines and Petroleum Resources, 1995). Geological compilations were not available for this extension at the time of the estimation workshop so estimates were made based on the 1:1 000 000 compilation of the Geological Survey of Canada (Journeay and Williams, 1995). The part of the Muskwa-Kechika area not compiled during the Northeast British Columbia project compilation was compiled as part of the Northwest British Columbia project (Figure 2). Expert estimations for this part of the area will be redone together with the rest of the northwest region in March of 1996.

## *REASSESSMENT OF REGIONS*

Starting with the Thompson-Okanagan expert-estimation workshop held in November of 1994, a new, more structured method of generating the estimates was used. This methodology improvement is described in a following section. The results of this workshop were significantly superior to earlier estimation efforts. As a result, a workshop was run in February 1995 to reassess the Skeena-Nass and Mid-Ccoast Regions using the improved format (Figure 2). During the current year it is planned to develop new estimates for the Vancouver Island, Cariboo and Kootenay regions and produce new evaluations. These reassessments will standardize the analysis of all regions to a single methodology. This will facilitate the comparison of tracts in neighbouring regions when land-use planning areas straddle boundaries of mineral potential regions.

## *DIGITAL OPEN FILE RELEASES*

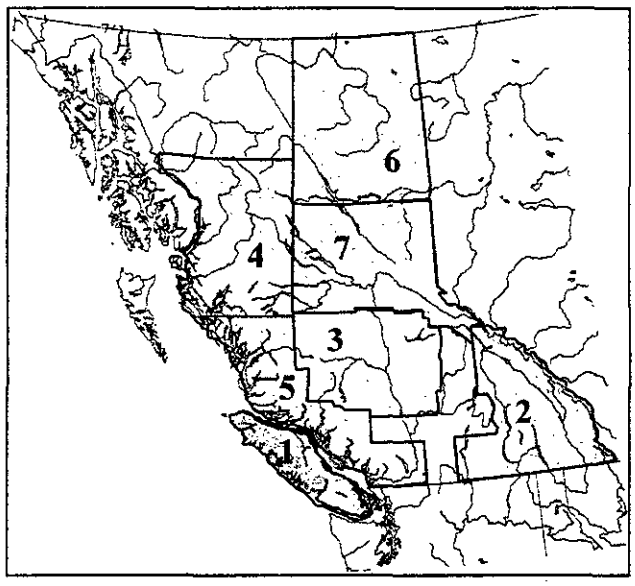


Figure 3. Map showing the locations of the Open File releases of geological compilations to date. Areas of digital geology releases; 1 - OF 1994-6 (Massey, 1994), 2 - OF 1994-7 (Schiarizza *et al.*, 1994), 3 - OF 1994-8 (Höy *et al.*, 1994), 4 - OF 1994-14 (MacIntyre *et al.*, 1994), 5 - OF 1994-17 (Bellefontaine and Alldrick, 1994), 6 - OF 1995-6 (MacIntyre *et al.*, 1995), 7 - OF 1995-24 (Bellefontaine *et al.*, 1995) and 8 - 1994-27 (Desjardins, 1994).

On completion of the geological compilation in each region, the information is made available by means of Open File Series releases. To date there have been eight such releases (Figure 3). Each release contains a set of diskettes holding the digital information, paper representations of the map legend, information sources and a copy of the digital data for reference. Some of the later releases contain a colour plotfile which can be used to produce a colour hardcopy map of the geology. This information can be used in CAD systems directly as it is presented, in an industry standard format (.DXF), or input into a GIS or desktop mapping system. Some additional effort will be required to build topology for the dataset in a GIS system, but the required information is provided in the releases. Comparable information in GIS-compatible

format is now being made available on the Internet (see later section).

## *NEW REQUIREMENTS PLACED ON ASSESSMENTS*

Output from this project was designed to meet the requirements of the Commission on Resources and Environment's land-use planning process. This process was implemented at a regional scale of 1:250 000. Since the original three CORE regions of Vancouver Island, Cariboo-Chilcotin and Kootenays were started, no additional CORE-style land-use planning processes have been undertaken. In place of the regional CORE process many subregional Land and Resource Management Plan processes (LRMP) have been initiated (Figure 4). The scale of these planning processes is typically more detailed than the 1:250 000 used in the CORE analysis. The accuracy of the point information and the mineral assessment tract boundaries is adequate for use at the scales being used in the LRMPs. However, the size of the mineral assessment tract polygons may be a concern at these more detailed scales.

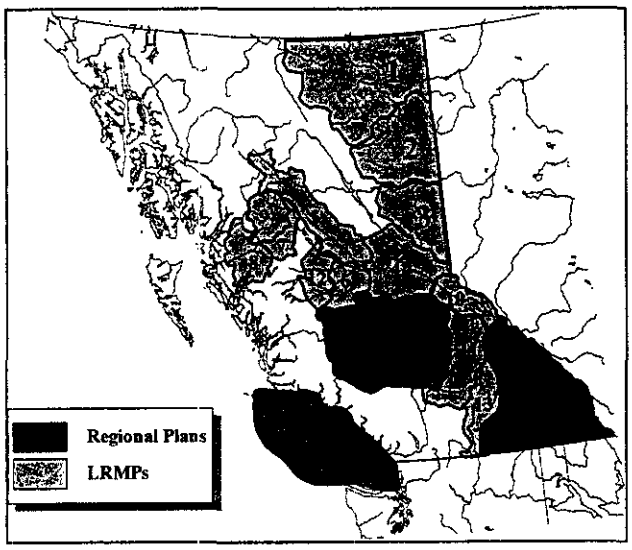


Figure 4. Map showing the locations of the regional CORE study areas and the more recent subregional Land and Resource Management Plans. A - Vancouver Island, B - Cariboo/Chilcotin, C - Kootenay, 1 - Fort Nelson, 2 - Fort St. John, 3 - Dawson Creek, 4 - Prince George, 5 - Fort St. James, 6 - Vanderhoof, 7 - Bulkley, 8 - South Kalum, 9 - Kispiox, 10 - Robson Valley, 11 - Kamloops, 12 - Lakes and 13 - Okanagan/Shuswap.

The tract polygons are the smallest unit on which estimates of future mineral discoveries are made. The estimation process treats the tract as a single homogenous unit. Estimated undiscovered deposits have no position within the tract but also cannot be assumed to be evenly distributed throughout the tract. When a LRMP is relatively small there may be few tracts in the study area. As a result there may not be sufficient detail available from the regional-scale analysis of the Mineral Potential Project to satisfy the more detailed land-use analysis being carried out for the LRMPs. This concern has not yet been expressed by land-use planners, but as more detailed analyses are performed, the value of the regional Mineral Potential Analysis will decrease. There are several options to address this problem, if it becomes a concern. Firstly, and most effective, would be the selection of smaller mineral assessment tracts based on smaller geological subdivisions and re-estimation of the potential discoveries in these smaller tracts. Alternatively, the deposit types estimated in the original tracts could be assigned, where possible, to "most likely" formations within the tract. In this way the finest resolution of the geological compilation would be made available.

# NEW METHODOLOGY

## *STRUCTURED ESTIMATION PROCESS*

Starting in November, 1994 a more structured method of collecting estimations was introduced. Earlier, industry and government experts received training on the estimation process and data packages for the region being estimated. They took this material away and made independent estimates for the tracts and deposit types for which they had significant expertise. As a result, not all tracts and deposit types received the same attention from the estimators.

A simple modification to this earlier process has resulted in a rigorous examination of all tracts and potential deposit types within a region. Now workshops of 3 to 5 days duration are held for each region, the estimators are divided into groups of three or four, and each group is responsible for estimating a class of deposits, for example skarns or porphyries. Usually there are five or six such groups, each working on a class of deposit types. The estimators in each group discuss the geology in each tract, using the information provided and adding their personal knowledge. Generally the groups work through the tracts in the region, examining each deposit type in their class of deposits, on a tract by tract basis. If they all agree that a particular deposit type is not possible in a tract, no estimate is made, but if one of the estimators feels there is a chance of a particular deposit type occurring in the tract, all the estimators in the group make a confidential estimate. As part of each estimate each estimator provides a confidential grading of the other estimators in the group, based on his or her perception of their knowledge of the tract and deposit type in question. These weights are used to combine the estimates generated by the group (see Grunsky and Kilby, 1996).

Advantages of this approach are:

- The estimation process is completed in less than five days.
- All tracts and deposit types are examined.
- Each estimate benefits from discussion between several experts (often more than 100 years of

collective experience is brought to play for a deposit type in a tract).
- A form of quality control is inherent in the expert-weighting process.

## *WEIGHTING OF FULL PROBABILITY SPECTRUM*

The subjective probability estimation process used provides a probability spectrum for each estimate; for each estimate, the number of deposits expected to be found in the future can be determined at various confidence values (Grunsky and Kilby, 1996). This probability spectrum of estimated deposits is used as input to the Mark 3 simulator (Root *et al.*, 1992) where it is combined with the deposit grade and tonnage probability information (Grunsky, 1995). Outputs from the simulator are probability spectrums for the tonnage of each commodity associated with the deposit type.

In earlier analyses, only the 50% confidence level was used for comparative purposes. It was found that a significant amount of information associated with low confidence levels was lost using this method. Now values from four confidence levels are used and weighted by their confidence in order to capture the full set of information that is available from the analysis. The confidence levels sampled are 90%, 50%, 10% and 1% and the associated weightings are .9, .5, .1, .01. These values can then be added to those from discovered deposits which have a 100% confidence level and weighting factor of 1.0.

## *METAL AND INDUSTRIAL MINERALS MAPS*

Metallic and industrial mineral commodities were grouped together during analysis early in the project. This grouping of two distinct types of commodities has caused difficulties in presenting meaningful results. Originally, end users desired only one map to represent mineral potential values. This requirement has changed and now more leeway is being allowed to accurately represent the various exploration and mining values of interest to the land-use planners.

In general, metallic commodities are sold into a general market with minimal processing and involving reletively low volumes. The ready market is there as long as the metellic element being sold is in demand and can be mined at a profit. Industrial minerals, on the other hand, tend to be far more dependent on specialized processing to meet limited specialized market requirements. Industrial minerals also tend to be bulk commodities, such as limestone, with very large tonnages of *in situ* resources, but with limited markets and transportation costs often rivaling mining costs.

To address these significant differences, two mineral assessment maps are now used to represent the mineral potential of a region; exactly the same tracts are used for each display.

## *METALLIC MINERAL ASSESSMENT RANKING*

The metallic mineral assessment ranking is made using the methodology described by Kilby (1995). The ranking is based on the gross in-place value of the metallic commodities in each tract, contained in both discovered and undiscovered deposits. The dollar value of the commodities in each deposit is used to generate a total dollar score for each tract. These dollar scores are then used to rank the tracts within the region.

## *INDUSTRIAL MINERALS ASSESSMENT RANKING*

The dollar value of the many industrial mineral commodities found in British Columbia is not an acceptable way to realistically compare their relative values. For example, it is relatively easy to locate a billion tonnes of limestone, but almost impossible to find a market for anywhere near this tonnage. Even at a very low dollar value per tonne, a deposit of this size would completely overshadow a much smaller deposit of some commodity that has a ready market. In this case, the large limestone deposit would be assigned a much higher value than the smaller deposit if simple dollar values were used to rank the commodities. An industrial mineral deposit ranking scheme has been established in an effort to overcome this problem.

A score of 1 to 100 is given to each type of industrial mineral deposit, ranking its perceived value. This value incorporates an estimate of product marketability if a deposit is found, and the overall value of the marketed product. The ranking has been done by experts in the industrial mineral field and a partial list is presented in Table 1.

**Table 1. Partial listing of industrial mineral deposit types with their ranking score.**

| Deposit Type | Ranking Score |
|---|---|
| Zeolites | 22.5 |
| Vermiculite | 27.5 |
| Mississippi Valley Type Barite | 35.0 |
| Residual Kaolin | 45.0 |
| Crystalline Flake Graphite | 65.0 |
| Asbestos | 95 |
| Diamond | 95 |

The final ranking score for industrial minerals is based on both discovered deposits and estimated future discoveries. For known deposits, the dollar value of all defined resources is summed for each tract, just as with metallic minerals. The tracts are ordered by this total discovered dollar value and then assigned an ordinal value from 1 to the total number of tracts (1 being the lowest).

The number of deposits expected to be discovered is multiplied by the industrial mineral deposit ranking value (Table 1) at four probability levels; these scores are compiled for each deposit type estimated in each tract. The probability levels used are .90,.50, .10 and .01. Once the values associated with all industrial mineral deposit types estimated have been compiled for each tract, the tracts are ranked by the scores associated with each of the four probability levels. An ordinal value from 1 to the total number of tracts is assigned to each tract for each of the four levels. The final ranking score for the tract is obtained by weighting the five ordinal scores and summing these values. The weighting values used for each probability level and the discovered deposits are the same as described in the above section on weighting the full probability spectrum.

## *PHASE 1 DISCONTINUED*

Phase 1 methodology, as described in Kilby (1995), was designed as an interim response to extremely short timelines. Its objective was to use existing information to estimate the tract ranking industry experts would produce through the more rigorous probability estimation process. The Phase 1 maps were easily understood by non-specialists, as simple weightings were applied to four historical parameters that had been collected for each tract. These maps have become popular with lay people and have in some cases been preferred over the much more predictive maps based on expert estimations. Every effort is now being made to discourage the use of these maps as indicative of the value of the landbase of a region.

The information used to compile the maps remains useful to represent the value of mineral exploration and mining in a region, but the Phase 1 derivative map produced from these data should no longer be used, as it has outlived its value. Much better maps are now available to illustrate the relative ranking of the landbase.

# MINERAL POTENTIAL INFORMATION DISTRIBUTION

## *OPEN FILE RELEASES ON DISKETTE*

Digital versions of the compiled geology have been released in the form of Open File publications since 1994. Eight such releases have been made (Figure 3), each covering a complete region or half a region. The information is placed on diskettes in a CAD format (.DXF) with supporting paper information such as a dump of the CAD linework, legend and reference list. The released information is adequate for incorporation into a GIS or simply used for CAD drawings.

## *ON-LINE ACCESS BY WWW - MINERAL POTENTIAL HOMEPAGE*

A Mineral Potential Homepage has been established on the World Wide Web to display and provide access to the results of the Mineral Potential Project and datasets generated by the project. The URL (Universal Resource Locator) for the site is http://www.empr.gov.bc.ca (Figure 5).

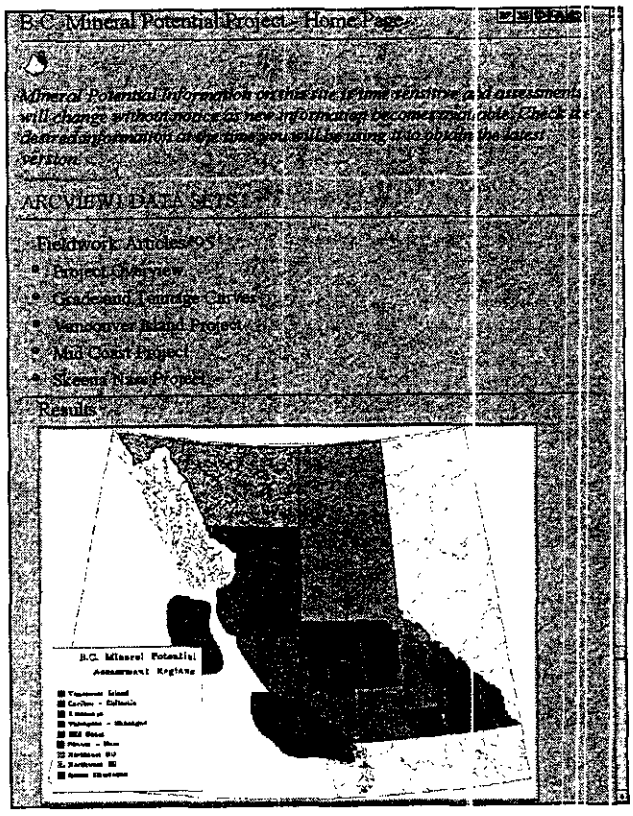


Figure 5. Mineral Potential Project World Wide Web homepage showing the various topics available.

### REPORTS AND ARTICLES

The homepage contains a section of hyperlinked articles describing various aspects of the Mineral Potential Project. The articles are hypertext copies from Geological Fieldwork 1994. Articles from Geological Fieldwork 1995, such as this one, will be added to this location.

### MINERAL ASSESSMENT MAPS (HYPERLINKED)

The results of the mineral assessments can be viewed interactively on the WWW site with a WWW browser. Colour maps of each analysed region are presented, showing the relative rankings of the tracts (Figure 6). The viewer can click on a tract of interest to obtain a table of information about the tract, such as the results of the

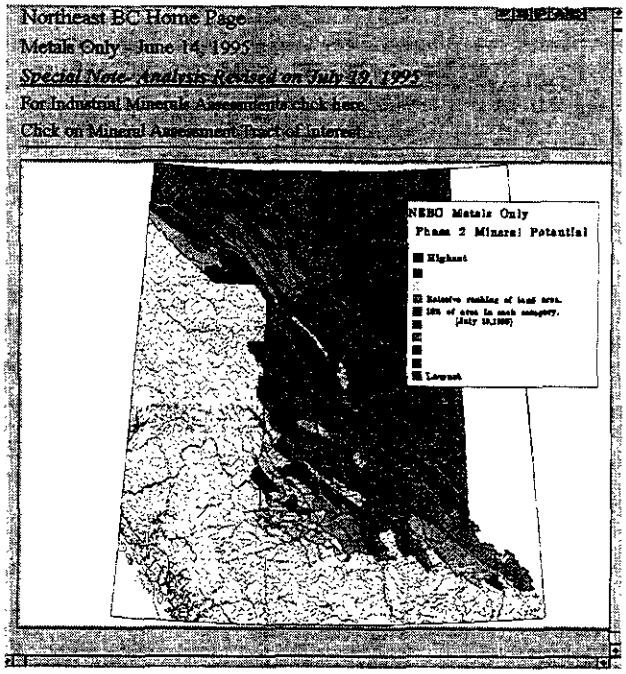


Figure 6. Example of a mineral assessment map accessible on the World Wide Web.

estimation process, mineral occurrences in the tract, tract area, value of past production, value of past exploration and the relative ranking of the tract (Figure 7).

## DOWN-LOADABLE DATA

In addition to being able to view the results of the mineral potential project interactively, information can be downloaded for subsequent analysis and use at no cost. The down-loadable data can be accessed through the Mineral Potential Homepage or through LANDDATA BC (accessible through the B.C. Government Homepage at http://WWW.GOV.BC.CA). All the datasets provided in this section have been placed in a single standard projection so they can be combined in any combination and retain their relative positions. The information is presented in one format at present: the Export (E00) format of ESRI. This allows easy importing to major GIS systems and is easily viewable by the freely available program ARCVIEW1 which can be accessed from the WWW site. This program runs on PC computers with the WINDOWS operating system. This powerful program allows users to produce a wide range of maps and derivative analyses from the datasets provided (Figure 8).

### *Mineral Assessments*

The results of the mineral assessment of each region are contained in individual ESRI Export files. A view file is attached in a single zipped file for convenience of downloading. The file contains information describing the shape of each mineral assessment tract and associated attribute information. The attribute information available

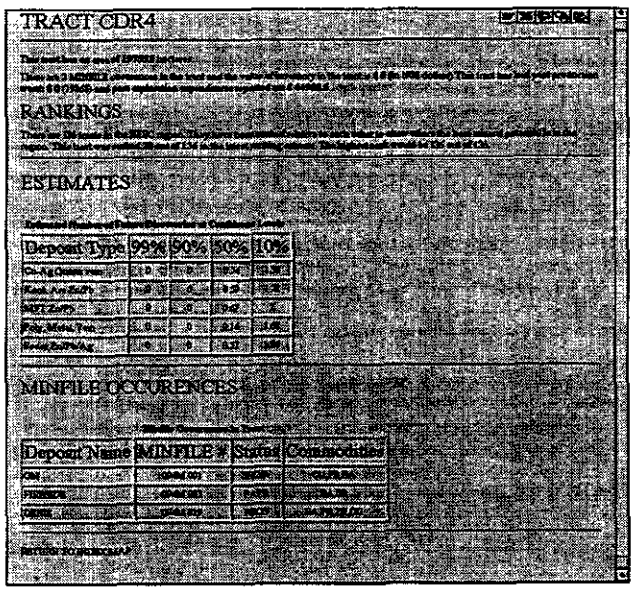


Figure 7. Example of a tract table which is hyperlinked to a tract on a mineral assessment map.

for each tract is: tract name, tract area, number of mineral occurrences in the tract, value of past production, value of past exploration reported, value of known resources (metallic), relative tract ranking with respect to metallic minerals, relative tract ranking with respect to industrial minerals, value of known resources (industrial minerals) and blank calculation fields.

Each of these attributes can be used for labeling, or to colour the tracts within the map area to illustrate the distribution of a desired variable, as shown in Figure 8.

### *Province-Wide Datasets*

Two base maps of the province are available for downloading. The file BC.zip contains a very simplified outline of the province with major waterways (see background of Figures 2 and 3). The file BCFULL.zip contains a much more detailed map of British Columbia useful, at scales as detailed as 1:500 000.

The file MINFILE.zip contains all the mineral occurrence data locations recorded in the MINFILE database (Jones and McPeek, 1992). In addition to the geographic location of the mineral occurrence, the following information is included in this subset of MINFILE: MINFILE number, map sheet name, deposit name, occurrence status, commodities and deposit type.

The file ARIS.zip contains the locations of all mineral assessment reports filed with the Ministry and recorded in the Assessment Report Information System (Kalnins and Wilcox, 1994). In addition to the geographic location of each report, the following information about the report is included in the file: Assessment Report number, confidentiality period, year of report and value of exploration work reported.

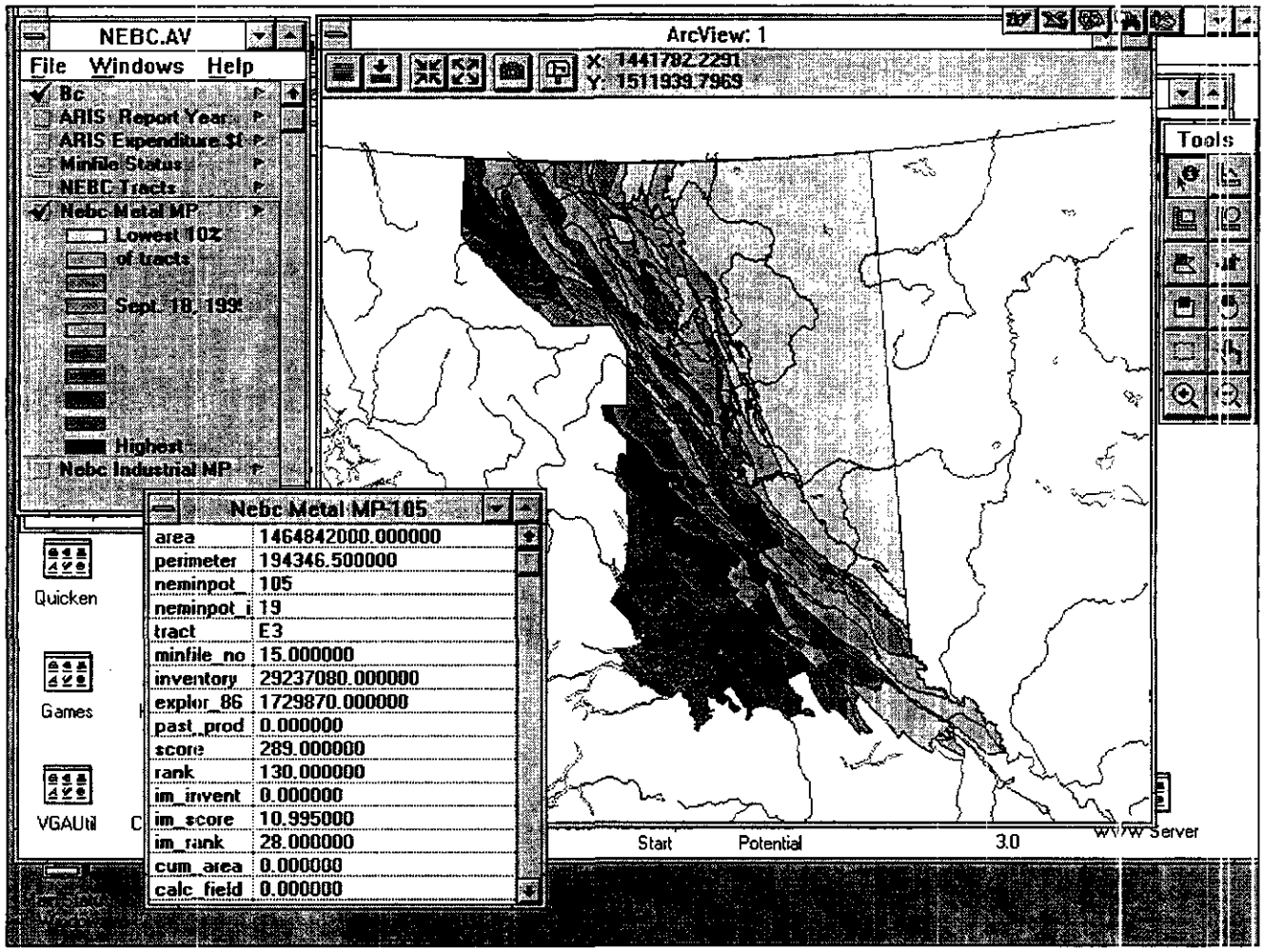


Figure 8. Arcview1 map of Northeast British Columbia Mineral Assessment data showing the map, legend, tool menu and the query menu.

The compiled geology for each region has been converted into the ESRI Export format. The regions have been divided into individual 1:250 000 map-sheet files to reduce file size and facilitate downloading over the Internet. Each map sheet is represented by three files; a geology polygon, geology linework and a view file are needed to completely illustrate the geology of a map sheet. The view files for all the maps within a region contain a standardized legend for the whole region. Views are also available that combine all the map sheets within a region. These geological maps are presented on an "as is" basis and are continually being upgraded.

## FUTURE

The next year of the project will see the completion of the analysis for the whole province. The Queen Charlotte Islands are all that will remain to be completed at the end of this year. By the end of next year all the mineral assessment data and compiled geology for the province will be available on the World Wide Web.

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