canadian centre for geoscience data
centre canadien des données géoscientifiques

GEOLOGICAL SURVEY
PAPER 75-20

MANIFILE: THE UNIVERSITY OF MANITOBA COMPUTER-BASED FILE OF WORLD'S NONFERROUS METALLIC DEPOSITS

P. LAZNICKA

Published by the Geological Survey of Canada

Department of Energy, Mines and Resources, Ottawa

1975

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

GEOLOGICAL SURVEY
PAPER 75-20

MANIFILE: THE UNIVERSITY OF MANITOBA COMPUTER-BASED FILE OF WORLD'S NONFERROUS METALLIC DEPOSITS

P. LAZNICKA

1975

Available by mail from *Information Canada*, Ottawa

from the Geological Survey of Canada
601 Booth St., Ottawa

and

Information Canada bookshops in

HALIFAX – 1683 Barrington Street
MONTREAL – 640 St. Catherine Street W.
OTTAWA – 171 Slater Street
TORONTO – 221 Yonge Street
WINNIPEG – 393 Portage Avenue
VANCOUVER – 800 Granville Street

or through your bookseller

A deposit copy of this publication is also available
for reference in public libraries across Canada

Price: $2.00 Catalogue No. M44-75-20

Price subject to change without notice

Information Canada
Ottawa
1975

CONTENTS

Illustrations

MANIFILE: THE UNIVERSITY OF MANITOBA COMPUTER-BASED FILE OF WORLD'S NONFERROUS METALLIC DEPOSITS

ABSTRACT

The need for a systematic compilation of data to support metallogenic research on a worldwide scale was met with development of a computer-based mineral deposit file called MANIFILE (University of MANItoba FILE of world's nonferrous metallic deposits). Data for the file were compiled mainly from published reports scattered through the international, multilingual literature of geoscience. Most data were edited, recalculated or reinterpreted, in order to achieve compatibility. Using the SAFRAS data management system, two sub-files comprising data on about 4 800 deposits, districts and metalliferrous areas of the world were built, which are estimated to account collectively for at least 85 per cent of the world's production and reserves of nonferrous metals. MANIFILE has provided effective support for research at the University of Manitoba in various ways, including the production of selective retrievals, graphic and map plots, and calculations required for analysis of the data.

RÉSUMÉ

Le besoin d'une compilation systématique de données, nécessaire à la recherche métallogénique à l'échelle mondiale, a été comblé par le développement d'un fichier informatique de gîtes minéraux appelé MANIFILE (University of MANItoba FILE – Fichier de l'Université du Manitoba des gîtes minéraux non-ferreux du monde). Les données nécessaires à la création du fichier furent compilées surtout à partir de rapports publiés, répartis à travers la littérature géoscientifique internationale et polyglotte. La plupart de ces données furent éditées, calculées ou réinterprétées, de façon à assurer leur compatibilité. Par l'utilisation du système SAFRAS de gestion de données, deux sous-fichiers furent construits, comprenant des données sur environ 4 800 gîtes, districts ou régions métallifères du monde, qui ensemble comprennent au moins 85 pour cent de la production et des réserves mondiales de métaux non-ferreux. Le fichier MANIFILE a fourni un appui efficace à la recherche à l'Université du Manitoba et ce, de plusieurs manières, entre autres par la production de récupérations sélectives, de tracés graphiques et cartographiques, et de calculs requis pour l'analyse des données.

INTRODUCTION

Origin of the File

The quantitative study of base and precious metal distribution on a worldwide basis was selected as a research topic by the writer in 1967 while studying at the University of Manitoba. The nature and scale of this research demanded access to systematically compiled data on the geology, geochemistry, economics, and other aspects of the world's mineral deposits, but it soon became evident that such a data base was not available. At about this time, as a result of work by the National Advisory Committee on Research in the Geological Sciences (Brisbin and Ediger, 1967), encouragement and financial support for the development of computer-based geological data files was offered from several sources (see Acknowledgments). This coincidence resulted in a decision to begin work on establishment of MANIFILE as a supporting data base for research in the field of metallogeny (Laznicka, 1970; Laznicka and Wilson, 1972; Wilson and Laznicka, 1972).

MANIFILE (University of MANItoba FILE of world's nonferrous metallic deposits) is a computer-based mineral deposit data file, designed according to the conceptual framework for such files presented by Brisbin and Ediger (1967, p. 54); thus the objects of description in the file are, basically, three-dimensional natural phenomenae called "mineral deposits". In MANIFILE most of the contained data are of a scientific, rather than economic or technological nature, with principal emphasis on geological, geochemical and metallogenic data. The file was built and processed with the SAFRAS system (Sutterlin and De Plancke, 1969; Pamenter, 1971) as installed on an IBM 360/65 computer at the University of Manitoba.

Data in MANIFILE were compiled, with few exceptions, from published reports scattered through the international, multilingual literature of geoscience. A considerable percentage of these data were edited, recalculated or reinterpreted before entering them in the file, and a substantial number of numerical estimates were made to fill gaps and to upgrade obvious deficiencies. Throughout these operations, however, clear distinction was maintained between *assured* and *estimated* data. Either both types were entered in parallel sequence, or a classification by degree of uncertainty was applied.

P. Laznicka
Department of Earth Sciences
University of Manitoba
Winnipeg, Manitoba R3T 2N2

Manuscript received: 1 May 1972
Approved for publication: 15 June 1972

Present Status

As of March 1972, MANIFILE consisted of two sub-files, as follows:

1. **File A,** completed in 1970 (Laznicka, 1970), contains data on approximately 4 000 deposits, districts and metalliferous areas of the world, each record containing a maximum of 214 data items.

2. **File B,** a slightly modified version of File A, contains data for about 800 deposits, districts and metalliferous areas in continental Australia only.

File A accounts for at least 90 per cent of the world's known resources of gold, silver, copper, zinc, lead, chromium, tin, tungsten, molybdenum, antimony and mercury. File B contains more recent and more comprehensive information on continental Australia, accounting for at least 95 per cent of her resources for these metals at the time of compilation, in addition to nickel, cobalt, bismuth, uranium, tantalam, columbium (niobium), platinum, iridium, and osmium. Both files are fully operative at the University of Manitoba computer centre and have been used for quantitative metallogenic studies such as the delineation of a copper/lead line in mineralized belts, determination of relationships between ore deposition and geological time on a worldwide basis, the construction of metallogenic maps; and various other applications (Laznicka, 1970; Laznicka and Wilson, 1972; Wilson and Laznicka, 1972).

Not yet included in MANIFILE are data in a manual file of about 3 000 cards which will be added in the future.

Worldwide coverage in MANIFILE is limited to a selection of the largest economic deposits and excludes, at present, small producers, deposits with no production or reserves recorded, showings and occurrences. For example, the file lists only 7 of 700 (1 per cent) known lead/zinc deposits and occurences in western Czechoslovakia; 140 of approximately 3 000 (4.7 per cent) more easily available recorded deposits in British Columbia; but less than 0.5 per cent of deposits and showings in the U.S.S.R., China and some other countries. Worldwide, it is estimated that File A includes between 0.5 and 0.7 per cent of all deposits and showings recorded and derivable from local reports and publications or available from local offices of Geological Surveys throughout the world. File B, when completed, may improve this percentage to between 1.0 and 1.5 per cent. In terms of the world's economic metal resources, however, these 0.5 - 0.7 per cent of presently recorded deposits account for at least 85 per cent of the world's production and reserves of nonferrous metals. Thus, the 99 per cent of unrecorded deposits and showings have relatively little effect on the worldwide metallogenic conclusions derived from MANIFILE.

Acknowledgments

Work on the development of MANIFILE has been financially supported by a number of grants received by the writer and by the Department of Earth Science, University of Manitoba, during the period 1967-1972. Included among these are the University of Manitoba Graduate Research Fellowship; the International Nickel Company of Canada Ltd. Graduate Research Fellowship; a Geological Survey of Canada grant recommended by the National Advisory Committee on Research in the Geological Sciences; and a National Research Council of Canada grant. This financial assistance is greatly appreciated.

Additional thanks are due to Mrs. S. Laznicka for her considerable technical assistance, to C. W. Hasselfield for computer programming, to Professor P. G. Sutterlin and his colleagues from the University of Western Ontario for their assistance with implementation of the SAFRAS system, and to Professor H. D. B. Wilson for supervising the project.

FILE DESCRIPTION

The contents of MANIFILE are summarized in tabular form (Tables 1, 2) using the format and terminology of SAFRAS, a generalized data base management system developed at the Department of Geology, University of Western Ontario (Sutterlin and De Plancke, 1969;) SAFRAS has been used in recent years by a number of Canadian and other institutions for geological applications, including several others involving mineral and fuel deposit data (Williams et al., 1972; Dickie and Williams, 1972). Accordingly, the second columns in Tables 1 and 2 list and classify the "data item names", under which MANIFILE data have been recorded. Data item names are grouped into "records", some of which may be repeated. The last two digits of the record number indicate such multiple records (e.g. Record 0201 is not repeatable, while Record 0403 may have up to 3 multiple records). The first two digits uniquely identify the records in the file (e.g. Record 0201 is record number 2, called "Economic metal content").

Complete documentation of data items included in MANIFILE is available in Laznicka (1970, p. 320 - 455; 564 - 644), which includes a topical manual for File A. The comments that follow are sufficient, however, for general understanding and appreciation of the contents of MANIFILE.

Record 01: Identification and Location

Deposits, districts and metalliferous areas are grouped hierarchically by physiographic and structural units, rather than political boundaries, and are identified by the data item called INDEX-NUMBER (Table 1). The type of index number used in File A proved to be impractical for retrievals and has been a constant cause of difficulty; thus, in File B it was replaced by a single number for every basic, indivisible unit (e.g. ROSEBERY MINE - 00576) and a range of numbers for a composite unit, for example that unit in which the Rosebery mine as well as other mines are contained (DUNDAS TROUGH - 00560 - 00588).

The NAME-OF-DEPOSIT-OR-AREA contains the simplest locality name most often used to identify the mineral deposit in the literature (e.g. SULLIVAN MINE, NORANDA-HORNE MINE, FLIN FLON DISTRICT, SUPERIOR PROVINCE). Although some of these names are generally known to Canadian geologists and students, many are unable to locate a number of the deposits on the map; for example, only two students out of a class of 36 knew that the Sullivan mine is in Kimberley, British Columbia. The problems are much greater for non-Canadians, or in turn for Canadians assessing the location of a deposit abroad. This problem has been eliminated in File B where the NAME-OF-DEPOSIT-OR-AREA data item always contains the name of a settlement, river, mountain, or other feature which is near the ore deposit and which can be easily located on an ordinary topographic

Table 1. Data specifications for File A, MANIFILE, using notational conventions of SAFRAS system (Sutterlin and De Plancke, 1969).

No.	Data item name	No. of Chara.	Alpha or numeric	% Subjectivity
001	**Record No. 0101**			
002	INDEX-NUMBER	009	AN	0
003	NAME-OF-DEPOSIT-OR-AREA	042	A	0
004	COUNTRY	004	A	0
005	LATITUDE	005	AN	0
006	LONGITUDE	006	AN	0
007	LATITUDE-LONGITUDE-REMARKS	001	A	0
008	**Record No. 0201**			
009	KIND-OF-ASSURED-DATA-1	002	A	25
010	KIND-OF-ASSURED-DATA-2	002	A	25
011	BASIS-FOR-ESTIMATE	001	N	25
012	OTHER-METAL-1	002	A	0
013	OTHER-METAL-2	002	A	0
014	OTHER-METAL-3	002	A	0
015	OTHER-METAL-4	002	A	0
016	OTHER-METAL-5	002	A	0
017	AU-ASSURED-CONTENT	006 03	N	0
018	AU-ESTIMATED-CONTENT	006 03	N	0
019	AU-GRADE	003 03	N	0
020	AU-GRADE-REMARKS	001	A	0
021	AG-ASSURED-CONTENT	006 02	N	0
022	AG-ESTIMATED-CONTENT	006 02	N	0
023	AG-GRADE	005 02	N	0
024	AG-GRADE-REMARKS	001	A	0
025	CU-ASSURED-CONTENT	009	N	0
026	CU-ESTIMATED-CONTENT	009	N	0
027	CU-GRADE	002 02	N	0
028	CU-GRADE-REMARKS	001	A	0
029	ZN-ASSURED-CONTENT	009	N	0
030	ZN-ESTIMATED-CONTENT	009	N	0
031	ZN-GRADE	002 02	N	0
032	ZN-GRADE-REMARKS	001	A	0
033	PB-ASSURED-CONTENT	009	N	0
034	PB-ESTIMATED-CONTENT	009	N	0
035	PB-GRADE	002 02	N	0
036	PB-GRADE-REMARKS	001	A	0
037	CR-ASSURED-CONTENT	009	N	0
038	CR-ESTIMATED-CONTENT	009	N	0
039	CR-GRADE	002 01	N	0
040	CR-GRADE-REMARKS	001	A	0
041	SN-ASSURED-CONTENT	008	N	0
042	SN-ESTIMATED-CONTENT	008	N	0
043	SN-GRADE	001 03	N	0
044	SN-GRADE-REMARKS	001	A	0
045	W-ASSURED-CONTENT	007	N	0
046	W-ESTIMATED-CONTENT	007	N	0
047	W-GRADE	001 03	N	0
048	W-GRADE-REMARKS	001	A	0
049	MO-ASSURED-CONTENT	007	N	0
050	MO-ESTIMATED-CONTENT	007	N	0
051	MO-GRADE	001 03	N	0
052	MO-GRADE-REMARKS	001	A	0
053	SB-ASSURED-CONTENT	007	N	0
054	SB-ESTIMATED-CONTENT	007	N	0
055	SB-GRADE	002 02	N	0
056	SB-GRADE-REMARKS	001	A	0
057	HG-ASSURED-CONTENT	007 01	N	0
058	HG-ESTIMATED-CONTENT	007 01	N	0
059	HG-GRADE	001 03	N	0
060	HG-GRADE-REMARKS	001	A	0
061	**Record No. 0301**			
062	REFERENCES	065	AN	0
063	NOTES-1	001	AN	0
064	NOTES-2	004	AN	0
065	NOTES-3	019	AN	0
066	**Record No. 0403**			
067	ROCK-UNIT-NAME	020	A	0
068	ROCK-UNIT-REMARKS	001	A	0
069	GEOLOGICAL-AGE-1	004	A	0
070	GEOLOGICAL-AGE-3	004	A	0
071	GEOLOGICAL-AGE-3	004	A	0
072	GEOLOGICAL-AGES-REMARKS	001	A	0
073	ABSOLUTE-AGE-1	004	N	0
074	ABSOLUTE-AGE-2	004	N	0
075	ABSOLUTE-AGE-REMARKS	001	A	0
076	STRUCTURAL-LEVEL-OR-CYCLE	002	N	25
077	STRUCT-LEVEL-OR-CYCLE-REM	001	A	0
078	GEOTECTONIC-CATEGORY	002	A	50
079	GEOTECTONIC-CATEGORY-REM	001	A	0
080	GEOTECTONIC-POSITION	004	A	50
081	GEOTECTONIC-POSITION-REM	001	A	0
082	DEVELOPMENT-STAGE	004	A	50
083	DEVELOPMENT-STAGE-REMARKS	001	A	0
084	ENVIRONMENT-OF-FORMATION	002	A	25
085	ENVIRONM-OF-FORM-REMARKS	001	A	0
086	ASSOCIATED-ROCK-1	002	A	10
087	ASSOCIATED-ROCK-2	002	A	10
088	ASSOCIATED-ROCK-3	002	A	10
089	ASSOCIATED-ROCK-4	002	A	10
090	ASSOCIATED-ROCK-5	002	A	10
091	ASSOCIATED-ROCK-6	002	A	10
092	ROCK-ASSOCIATION-REMARKS	001	A	0
093	DEFORMATION-AND-METAMORPHISM	002	A	10
094	DEFORM-AND-METAM-REMARKS	001	A	0
095	ENCLOSING-ROCK-1	004	A	5
096	ENCLOSING-ROCK-2	004	A	5
097	ENCLOSING-ROCK-3	004	A	5
098	ENCLOSING-ROCK-4	004	A	5
099	ENCLOSING-ROCK-5	004	A	5
100	ENCLOSING-ROCK-6	004	A	5
101	ENCLOSING-ROCKS-REMARKS	001	A	0
102	SPACE-ORE-RELATIONSHIP	001	A	25
103	TIME-ORE-RELATIONSHIP	001	N	0
105	**Record No. 0501**			
106	GENETIC-TYPE-1	004	A	75
107	GENETIC-TYPE-2	004	A	75
108	GENETIC-TYPE-3	004	A	75
109	GENETIC-TYPES-REMARKS	001	A	0
110	SUPERGENE-CHANGES	004	A	0
111	SUPERGENE-MAGNITUDE	002	N	0
112	SIMILARITY-TYPE	004	A	50
113	SIMILARITY-TYPE-REMARKS	001	A	0
114	SHAPE-OF-OREBODIES-1	004	A	25
115	SHAPE-OF-OREBODIES-2	004	A	25
116	SHAPE-OF-OREBODIES-3	004	A	25
117	SHAPE-OF-OREBODIES-REMARKS	001	A	0
118	MINERAL-1	004	A	0
119	MINERAL-2	004	A	0
120	MINERAL-3	004	A	0
121	MINERAL-4	004	A	0
122	MINERAL-5	004	A	0
123	MINERAL-6	004	A	0
124	MINERAL-7	004	A	0
125	MINERAL-8	004	A	0
126	MINERAL-REMARKS	001	A	0
127	DEPOSITION-AGE-1-A	004	AN	25
128	DEPOSITION-AGE-1-B	004	AN	25
129	DEPOSITION-AGE-1-C	004	AN	25
130	DEPOSITION-AGE-1-REMARKS	002	A	0
131	DEPOSITION-AGE-2-A	004	AN	25
132	DEPOSITION-AGE-2-B	004	AN	25
133	DEPOSITION-AGE-2-C	004	AN	25
134	DEPOSITION-AGE-2-REMARKS	002	AN	0
135	DEPOSITION-AGE-3-A	004	AN	25
136	DEPOSITION-AGE-3-B	004	AN	25
137	DEPOSITION-AGE-3-C	004	AN	25
138	DEPOSITION-AGE-3-REMARKS	002	A	0

Table 2. Data specifications for File B, MANIFILE, using notational conventions of SAFRAS system (Sutterlin and De Plancke, 1969).

No.	Data item name	No. of Chara.	Alpha or numeric
139	**Record No. 0601**		
140	NEW-NUMBER	009	N
141	DEPOSIT-CATEGORY	001	A
142	LOCATION	035	AN
143	DEPOSIT-DESCRIPTION	045	A
144	ROCK-GROUP-DESCRIPTION-1	053	A
145	ROCK-GROUP-DESCRIPTION-2	053	A
146	ROCK-GROUP-DESCRIPTION-3	053	A
147	OREBODY-ATTITUDE-1	003	A
148	OREBODY-ATTITUDE-2	003	A
148a	OREBODY-ATTITUDE-REMARKS	001	A
149	NOTES-4	001	A
150	NOTES-5	001	A
151	NOTES-6	004	A
152	NOTES-7	004	A
153	NOTES-8	004	A
154	NOTES-9	005	AN
155	**Record No. 0701**		
156	NI-ASSURED-CONTENT	008	N
157	NI-ESTIMATED-CONTENT	008	N
158	NI-GRADE	001 03	N
159	NI-GRADE-REMARKS	001	A
160	CO-ASSURED-CONTENT	007	N
161	CO-ESTIMATED-CONTENT	007	N
162	CO-GRADE	001 03	N
163	CO-GRADE-REMARKS	001	A
164	BI-ASSURED-CONTENT	007	N
165	BI-ESTIMATED-CONTENT	007	N
166	BI-GRADE	001 03	N
167	BI-GRADE-REMARKS	001	A
168	U-ASSURED-CONTENT	008	N
169	U-ESTIMATED-CONTENT	008	N
170	U-GRADE	001 03	N
171	U-GRADE-REMARKS	001	A
172	NB-ASSURED-CONTENT	008	N
173	NB-ESTIMATED-CONTENT	008	N
174	NB-GRADE	001 03	N
175	NB-GRADE-REMARKS	001	A
176	TA-ASSURED-CONTENT	007	N
177	TA-ESTIMATED-CONTENT	007	N
178	TA-GRADE	001 03	N
179	TA-GRADE-REMARKS	001	A
180	PT-ASSURED-CONTENT	006 03	N
181	PT-ESTIMATED-CONTENT	006 03	N
182	PT-GRADE	003 03	N
183	PT-GRADE-REMARKS	001	A
184	OS-ASSURED-CONTENT*	005 03	N
185	OS-ESTIMATED-CONTENT	005 03	N
186	OS-GRADE	003 03	N
187	OS-GRADE-REMARKS	001	A

* OS (Osmium) includes iridium.

map (e.g. SULLIVAN MINE-KIMBERLEY). Similarly, the administrative mining divisions such as the "Goldfields" in Australia and "Districts" in Ontario have been avoided, whenever possible. Few people knew (before the twin cities of Port Arthur and Fort William were renamed), what constituted the Thunder Bay District in Ontario, and few geologists know that the famous Kalgoorlie gold district is located in the East Coolgardie goldfield. To avoid this confusion, groupings based on topography or structure of the area were found to be preferable.

Location is given by longitude and latitude in degrees and minutes in File A, and descriptive location (distance and direction) from a nearby settlement, mountain, etc. which can be found on current topographic maps, has been added in File B. Such precision is sufficient for plots on scales of 1:2 500 000 to 1:1 000 000, appropriate for the purpose of this file.

Record 02: Economic Metal Content

The total metal content[1] of Au, Ag, Cu, Zn, Pb, Cr, Sn, W, Mo, Sb and Hg in File A, plus Ni, Co, U, Bi, Ta, Nb, Pt, Ir, Os in File B, always expressed in metric tons (or kilograms) of pure metal content above a minimum cut-off grade, is entered. It was found advisable to convert metal quantities to metric units before entering them, rather than entering them using the units in which they are listed in the original source literature (e.g. short or long tons of ore; lbs; ozs; dwt. of contained metal; dollar values; concentrates, etc.) and relying on subsequent computer recalculation. Failure to convert to a common unit always leads to some errors, often very serious ones. Besides, the total metal content for numerous localities has had to be built up by a painstaking compilation of fragmental data and, for this purpose a common denominator is essential prior to entering these data in the file. This is illustrated in Table 3.

Metal content has been listed in two parallel sequences: ASSURED-CONTENTS, which are the uncorrected data (but possibly recalculated to metric units) available from the literature, and ESTIMATED-CONTENTS which may be either the same as the assured contents if the literature data are reasonably complete, or they may differ to varying degrees (in most cases greater) from the assured content. The estimates were always based on the geological and geo-economic knowledge of the deposit or a district, not on the economically biased projections of economic needs of various countries, and were prepared by interpolation and extrapolation of information gaps, by approximate reserve calculations based on the size of orebodies and grade where they were known, and by indirect methods. This subject is more thoroughly reviewed in the Manual (Laznicka, 1970).

The nature of the assured data, such as old production, one-year production, recent reserves, etc. are classified using a mnemonic code in the KIND-OF-ASSURED-DATA, and the reliability of the estimate is similarly classified in the BASIS-FOR-ESTIMATE, where 0 indicates no estimate at all (assured content = estimated content) and 1-9 indicate progressively decreasing reliability.

OTHER-METAL data items in File A served to list additional metals such as Ni, Co, U, etc., present in a deposit, by symbols only.

[1]The "total metal content" is a quantity of metal above a minimum cut-off grade which stands closest to the metal quantity originally present in the deposit shortly before the arrival of man, for example:

- The metal content in reserves of newly discovered deposits,
- the total past production of a deposit completely mined out,
- the total past production plus remaining reserves of presently mined deposits. The percentage of metals lost during the production should be added.

Table 3. Compilation of "metal content" figures from fragmental data, illustrated by example of Cananea copper district (Sonora, Mexico) from Laznicka (1970).

Note: all tonnage figures are for pure metal content and were mostly calculated from ore tonnage and grade. The framed data are added in the subtotal.

Step 1. Data from literature

1.	Perry (1935)	total prod. to 1932	533 000 t Cu (elimin. by 4/) 643 t Ag (elimin. by 2/) [4.8] Au
2.	Min. Yearbooks	total prod. to 1946	750 000 t Cu (elimin. by 4/) [707.5] Ag
3.	Schneider (1963)	grade 0.7% MoS_2	elimin. as improbable, because not expressed in Mex. product.
4.	Velasoo (1966)	total prod. to 1963 (?)	[1 133 000] t Cu
5.	Min. Yearbooks	total Mo. prod. of Mexico to 1967, of which Cananea at least 95%	[8 500] t Mo
6.	Mines Register (1966)	Prod. 1964-65	[60 000] t Cu [36] t Ag [0 8] Au
7.	World Mining, Dec. 1968	Reserves 1968	[1 434 000] t Cu
8.	World Mining, Nov. 1962	Reserves 1962	460 000 t Cu (elim., overlap with 4/ and 7/)

First subtotal gives "literature data" for most of the Cu production and reserves (only 3 years gap), fraction of Au P+R, fraction of Ag P+R, total xo production till 1967 and no data at all for Pb and zn, which are also reported as having been extracted.

2 567 000 t Cu	FIRST
5.6 Au	SUBTOTAL
743.5 Ag	
8 560 t Mo	

Step 2. Calculated gaps

Copper- 3 years production gap calculated by interpolating the 1964-65 production (60 000 t Cu) x 3 = 180 000 t Cu.

added total production + res. 2 567 000 t Cu.

---

2 747 000 t Cu= calculated

Other metals are calculated by the relation of each metal to Cu under the assumption that their ratios are constant.

5.6 t Au :	593 000 t Cu	= x :	2 747 000 t Cu
743.5 t Ag :	810 000 t Cu	= x :	2 747 000 t Cu
8 560.0 t Mo :	1 313 000 t Cu	= x :	2 747 000 t Cu

Total "literature" or "assured" and calculated content of metals in Cananea is therefore:

2 747 000 t Cu	2 520 t Ag
17 900 t Mo	25.9 t Au

Step 3. Pure estimated

The estimate is done by analogy with similar deposits in the United States, within the limit of known Pb and Zn production of the State of Sonora:

25 000 t Pb 20 000 t Zn

Total estimated content of the Cananea district is therefore:

2 747 000	t Cu
25 000	t Pb
20 000	t Zn
17 900	t Mo
2 520	t Ag
25.9	t Au

Record 03: References

The source of original information is referred to by the name of the author and the two last digits of the year of publication. Full references are being kept in a card file which, it is hoped, will be computerized in the future.

Record 04: Geological Environment

This record consists of three repeating records, each containing a rock group with a specific position in regard to the geotectonic cycle of which the listed mineral deposit is a member. If there are more than three rock groups, two or more may be grouped together (e.g. Takla and Hazelton Groups in the Western Cordillera), or the less important ones may be omitted, at present.

Record 0401 contains a rock group which can be called a "basement" either in the truly geological sense, or in the sense of the oldest group whose presence is believed to have been essential for the formation of a mineral deposit. It is most frequently an assemblage formed in the initial or early stages of geosynclinal development, or a consolidated, commonly metamorphosed, granitized portion of the earth's crust formed in previous orogenic cycles.

Record 0402 can be briefly characterized as an "active igneous body" and designates intrusive, or less commonly, extrusive rocks emplaced generally during or after the conversion of the geosynclinal or other sedimentary basin into a folded belt, with which the deposit is believed to be roughly contemporary. "Passive" granitic batholiths formed in previous epochs are included in the record 0401, even if they are host-rock for the ore deposit.

Record 0403, "superimposed unit", comprises younger sedimentary and volcanic units superimposed on the "basement" in the form of successor basins, intermontane troughs and new, superimposed geosynclinal cycles. They may be contemporary with ore deposition or older. Post-mineralization cover without influence on the formation of the ore deposit is not listed at present.

For example, in the Cobalt-Gowganda silver area, the Archean is a "basement", Huronian is the "superimposed unit" and the Nipissing Sill is the "active igneous body".

Each geological unit contains the following data items which are present in almost every file on the same subject and need no further comment: ROCK-UNIT-NAME, GEOLOGICAL-AGE, ABSOLUTE-AGE, DEFORMATION-AND-METAMORPHISM, and ENCLOSING-ROCK-1-6. The remaining data items (Tables 1, 2) require more detailed explanation.

The relation of the rock group to its broader environment and its place in the development history is treated in a group of four interrelated data items: structural level or cycle, geotectonic category, geotectonic position, and development stage.

STRUCTURAL-LEVEL-OR-CYCLE is considered to be a complex of rocks formed within a defined, usually long geological period of time (usually Periods, portions of Periods or groups of Periods) and delineated from its lower and upper neighbours by a boundary of broad (global) validity. Structural levels and cycles are coded by numbers and these numbers allow for an approximate mutual correlation within contemporary cycles. For example, "4" is a lower Paleozoic (Caledonian, Taconic) cycle or structural level in all Meso-Cenozoic orogenic belts of the world.

GEOTECTONIC-CATEGORY is the distinction of geosynclinal orogenic belts, non-geosynclinal orogenic belts, independent and superimposed basins and troughs, platforms, regions of activation, etc.

GEOTECTONIC-POSITION provides information as to which part of a respective geotectonic model the rock unit formed, and the DEVELOPMENT-STAGE (or phase) furnishes the relative time of formation. In the case of geosynclinal orogenic belts, the "geotectonic position" is based on the morphological classification proposed by Aubouin (1965) and the "development stage" is based principally on slightly modified results of the Soviet school (Bilibin, Smirnov and others). Schematic tables of the world's stratigraphy prepared in conformity with the classification and terminology used throughout the file are available in Laznicka (1970, p. 564-644).

A group of six data itmes called ASSOCIATED-ROCK lists characteristic lithologic associations, even if these rocks are not the immediate hosts to the orebodies. They are, unlike the ENCLOSING-ROCK, listed in their pre-metamorphic state, e.g. shales, mudstones, limestones, or basic lavas, instead of phyllites, gneisses, amphibolites, etc.

The last two data items, SPACE-ORE-RELATIONSHIP and TIME-ORE-RELATIONSHIP mutually relate the rock unit and the enclosed mineral deposit in space (e.g. conformable with the bedding, conformable with schistosity, disconformable, etc.) and in time (ore formed before, during, shortly after, and long after the formation of the rock unit).

The classification of the geological environment surrounding the mineral deposit in space and time, by codes corresponding to the easiest recognizable categories, proved to be unsatisfactory in actual application. One reason for this was that the key categories are seldom present in their "model" form in nature; more often they are partially developed, defective, embryonic, or affected by interaction with various envrionments, by subsequent metamorphism, etc. There is not enough space in the file to code and tabulate all possible deviations and transitions.

Another reason is the fact that the source literature which supplied the data spans a period of more than 70 years, and being multilingual, it incorporates several schools of thought, frequently diametrically opposing each other. The extraction of genetic data and their classification rested, in the last analysis, with the file compiler and has been highly subjective. Finally, the geosynclinal theory on which the classification used in File A is based, is being gradually replaced by the "new tectonics", although not without problems and reservations, which are especially strong in the U.S.S.R.

Of the possible ways available to the writer for improving data on this subject (widen the present classification to accommodate instances departing from the model; use short colloquial descriptions; build a new classification based on the "new tectonics"), the second has been chosen as an immediate remedy and applied to the Australian deposits comprising File B, while at the same time new classifications and new ways of expression are being tested.

Record 05: Mineral Deposit Proper

This record contains the following data items which are omnipresent in files of similar purpose: GENETIC-TYPE (e.g. magmatic segregation, hydrothermal plutonic), SUPERGENE-CHANGES and SUPERGENE-MAGNITUDE, and SHAPE-OF-OREBODIES (e.g. fissure veins, disseminations). Minerals (MINERAL-1-8) are listed according to decreasing quantities, by four-letter codes.

The following data items depart somewhat from the common pattern:

SIMILARITY-TYPE is a temporary item, the main purpose of which is to facilitate retrieval of deposits possessing certain similarities to which it is frequently referred in the literature either by one of the best examples (e.g. Sudbury type), or by the composition of morphology of ore bodies (e.g. massive sulphides, porphyry coppers). Fifty similarity types, grouped by the principal contained metals, are listed and characterized in the manual. Moreover, a provision is made to list the predominating similarity types in case more than one is present or when a deposit can be interpreted as being composed of a combination of two or more types. One of the future tasks is to define the similarity types quantitatively and base them on a fixed set of features.

The DEPOSITION-AGE data item consists of three groups of data items. The choice of either of the deposition ages 1-3 can be made on the supposition that a considerable number of mineral deposits show an overwhelming statistical relation to a particular kind of host and associated rocks. This can be explained either by particular favourability of these rocks for mineral deposition or by an idea that certain mineral deposits have apparently formed by a gradual, step-by-step concentration of metals originally present in a broader environment. This subject is more thoroughly discussed in Laznicka's (1970) Ph.D. thesis.

DEPOSITION-AGE-1 marks an appearance of products of large-scale depositional processes such as the sedimentation and volcanism in geosynclinal troughs. The REMARKS data item following DEPOSITION-AGE-1 distinguishes whether the indicated time actually means the formation of a mineral deposit (e.g. geosynclinal-type massive sulphides), or only formation of an envrionment enriched in trace metals or an otherwise favourable envrionment in which ore deposition took place later, by interaction with subsequent tectono-magmatic processes.

DEPOSITION-AGE-2 includes mainly the times of deposition roughly contemporary with the granitic magmatism or metamorphism as well as with sedimentation in successor basins, such as intermontane, foredeep troughs, etc.

DEPOSITION-AGE-3 gives the time of proved or inferred regeneration of previously formed deposits, and ore deposition connected with late shallow plutonism and subvolcanism, commonly leading toward the formation of exceptionally high ("bonanza") accumulations of metals.

The latest supergene changes in ore deposits, such as formation of laterites and placers should, no doubt, be included in a "DEPOSITION-AGE-4" data item. This age is, however, missing in the file at present and for purposes of retrieval all such processes are considered to be Cenozoic.

PROBLEMS ENCOUNTERED IN DATA COMPILATION

The present file differs from the majority of geological and mining data files currently in use in Canada in the following aspects: 1) Coverage is global in scope; 2) the contained information has been gathered from the published literature of many languages spanning a long period, and 3) the file contains a high percentage of subjective data and quantitative estimates.

These aspects are responsible for most of the difficulties encountered during data compilation and apparently are likely to contribute to future problems connected with retrievals. The first aspect makes it almost impossible to retain all the data items that are specifically Canadian or North American and to use fully Canadian geological terminology, weight units, methods of location, and similar items. The second and third aspects imply that the content of the file is not a result of the author's or an institution's observation, measuring, analysis, etc. nor an officially organized approach for which the data were requested from third parties by questionnaires with standard categories. It depends on available published literature in which the selection of topics and topographic areas was random and uneven.

Moreover, while a typical bibliographical reference records exactly "who said what and where it was published", the task in compiling this file was often to express in codes and fixed classification the most likely situation even if the original author reached an entirely different conclusion. For example, carbonatites were not recognized in the pre-World War II literature, and were generally described as marbles. They can, however, be safely identified from a good geological description as well as from locality listings in the recent literature. In this and similar cases the "marble" of the original author has been replaced by "carbonatite" by the compiler. Thus, even though the source of data is given in the file, the file entries are not necessarily direct quotations but are results of re-interpretation and modernization on the part of the compiler. Similar re-interpretations are commonplace in geological literature, but there they are discussed and explained; in a computerized file this is generally impossible. There is, naturally, a danger that the re-interpretation may be wrong, that re-interpretation has not been made in one case while in another, etc. For this reason, factors of subjectivity and uncertainity are discussed in the Manual (Laznicka, 1970).

Subjectivity can be defined as a way of presentation of a certain subject that is discussed, stated or described in the literature but which can be interpreted differently. In the file it is not marked, but the approximate degree of subjectivity that may affect various data items is specified in the Manual.

Uncertainty means that there simply is no answer on a given subject in the literature, or that several alternatives are listed, no matter whether the subject itself is unequivocal or whether it permits subjective interpretation. The compiler of the file introduced the answer either by selecting a proposed alternative or by using an analogy, an indirect proof or a comparison.

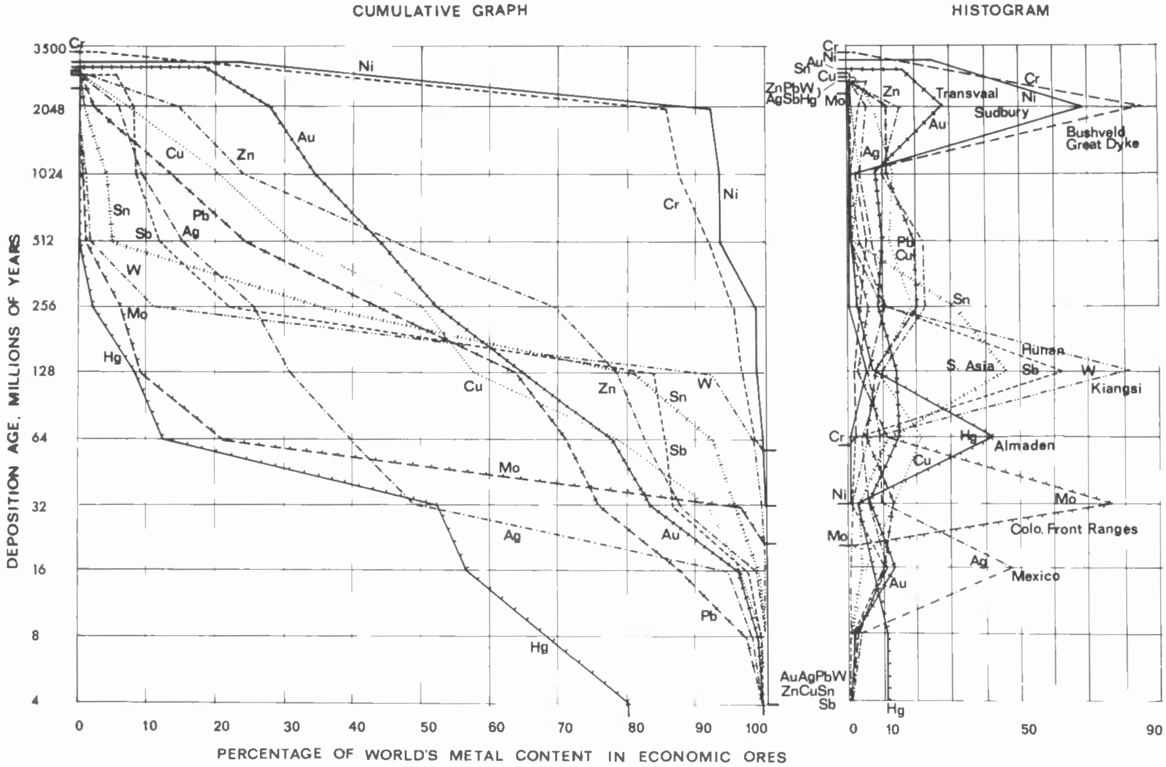


Figure 1. Deposition ages of world's deposits of 12 nonferrous metals. The ordinate scale is a geometric progression, the abcissa is arithmetic progression. From Laznicka (1973, Fig. 1).

From the standpoint of the user of the file the difference between subjectivity and uncertainity is that the statements with a high degree of subjectivity can be changed by everyone whose background in a particular subject differs from that of the file compiler, without the need to read the same literature, whereas in the case of uncertainity the code should not be changed unless the user has a better source of information than the file compiler had.

APPLICATIONS OF MANIFILE

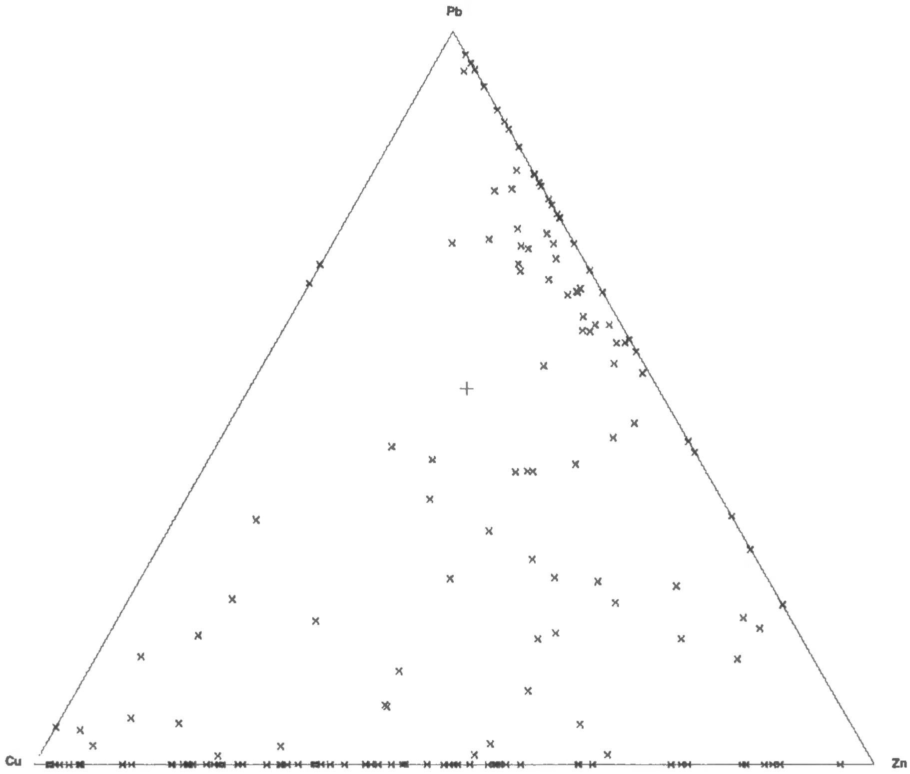
As already indicated in the Introduction, the University of Manitoba file of world's nonferrous metal deposits (MANIFILE) is essentially an academic file, primarily designed for basic research in regional and general metallogeny. File A was in fact compiled as a source of data for the writer's Ph.D. thesis (Laznicka, 1970) and this thesis, devoted to certain quantitative aspects of the world's metallogeny of nonferrous metals, itself serves as an example of possible uses of the file.

Following are some examples of uses which have yielded satisfactory results:

1. **Simple retrievals.** Listings of deposits in a certain area; in a certain structural unit; of a certain metal; of a certain age; in a certain host rock; of an identical "similarity type"; with a certain grade; with a certain minimum tonnage of contained metal; located in eugeosynclines; located north of 55 parallel; containing certain minerals; etc. The listings can be alphabetical, by size, by country, by structural unit, etc.

2. **Retrievals with graphic plots.** For example, a map plot of all deposits in a certain area; a plot of Pb-Zn deposits locally or worldwide; a plot of Devonian deposits locally or worldwide; a plot of massive sulphide deposits or porphyry coppers; etc.

3. **Retrievals with simple calculations (totalling).** Calculation of the world's content of certain metals in economic ores (assured and estimated contents); the world's or a certain area's content of copper or other metals in porphyry coppers, massive sulphides, etc; total metal content in deposits formed during the Triassic; total quantities of metals associated with andesites, etc. Using a program for a transfer of letter-coded geological ages to their numerical equivalents (e.g. DVNN = Devonian has a range of absolute ages 405-354 m.y.; the Cretaceous-Paleogene boundary = Laramide orogeny, has an approximate equivalent age of 63 m.y.), metal totals deposited in various geological ages, related to igneous intrusions of various ages or enclosed in host rocks of various ages can be calculated and a sequence of ore depositon in the earth's crust history plotted in a diagram (Figure 1).



Straight sums are: 0.43798E 08 0.40540E 08 0.85042E 08

Figure 2. Computer plot of Cu-Zn-Pb ratios in world's largest deposits of pyritic massive sulphides.

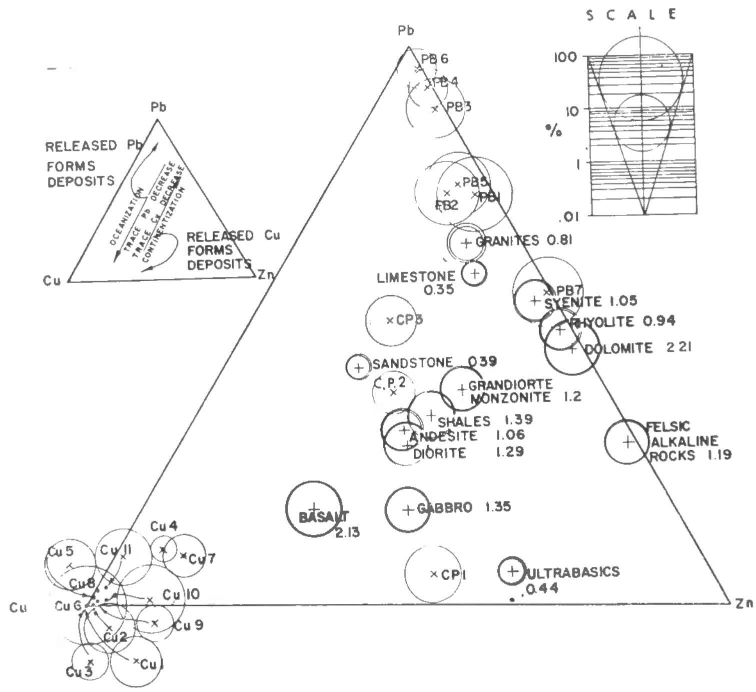


Figure 3. A diagram showing Cu-Pb-Zn relationships in the principal world copper-and lead-bearing ore types and in rock groups. See Laznicka and Wilson (1972, Fig. 4) for technical explanation and details.

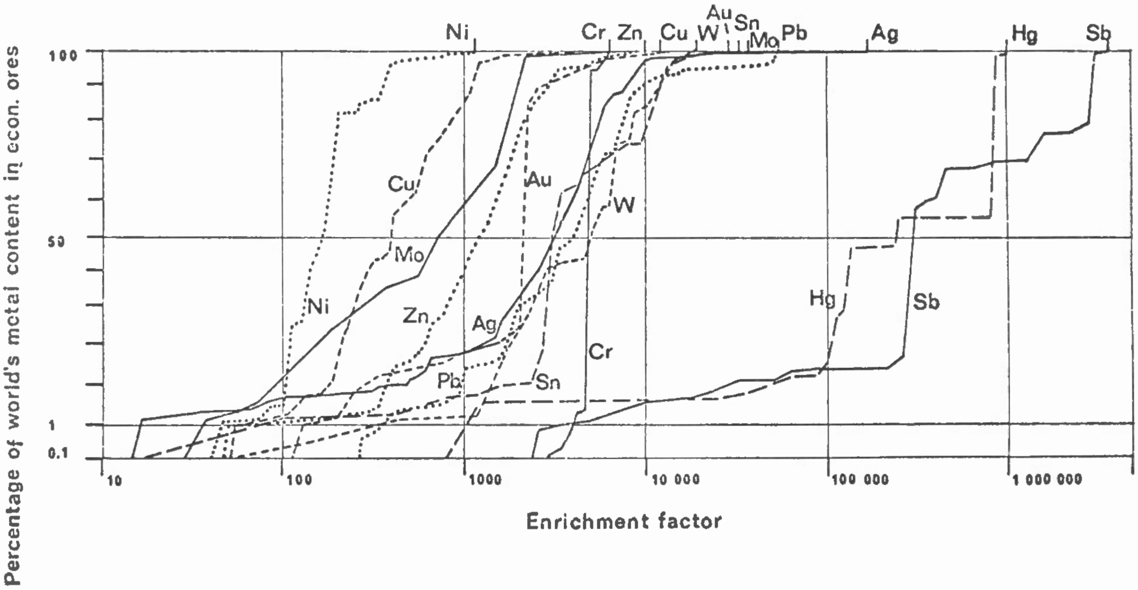


Figure 4. Computer-plotted (but subsequently redrafted) percentage/enrichment factor relationships of nonferrous metal deposits of the world.

4. **Retrievals with more complex calculations.** This usually involves the retrieval of data using COBOL language and subsequent recalculation in FORTRAN. Examples: Calculation of the average size of deposit of certain metals and certain ore types; ratios of metals in ore types (Figures 2, 3), metallogenic provinces and belts, age groups, etc; calculation of the world's average arithmetic and geometric mean grades of nonferrous metal ores (Figure 4); derivation of the magnitude of geochemical accumulation of elements in ore deposits by calculating "accumulation indexes" and "crust equivalents" (Laznicka, 1970) and their use in map plots; and magnitude of the geo-economic accumulation of metals in a deposit expressed in quantities of "normative ore" (Laznicka, 1970). Most of these calculations can be plotted directly on maps and diagrams.

All of the above-mentioned retrievals and calculations are most conveniently done on a global scale, with a degree of precision corresponding to map scales of approximately 1:10 000 000 to 1:5 000 000 for File A, and 1:5 000 000 to 2 500 000 for File B.

It must be emphasized that the file is of little use if applied to small territories (such as the Kamloops-Ashcroft-Merritt metalliferrous area), as it appears, for example, on the 1:5 000 000 geological map of Canada. The geological map of a large area will, however, show the continent- wide continuation and correlation of the zone of which the above-mentioned metalliferous area is a member, especially if the data are computer-plotted on a map.

FUTURE OF THE FILE

The use of the file is limited by: 1) The quantity of data items; 2) the quantity of records (ore deposits, districts and metalliferous areas); and 3) by the abundance of data in both. These quantities, in turn, depend on the availability of time, personnel and funds. The present MANIFILE is a result of 4.5 years' effort by one compiler, one technical assistant and a part-time computer programmer. It has been sponsored by the grants acknowledged above. If the research continues (supporting funds are now being received by the sale of copies of the file by the University of Manitoba), it is planned to ultimately upgrade File A to the standard of File B worldwide. Such a file would list about 8 000 - 10 000 deposits, districts and metalliferous areas of the world, each containing about 260 data items. The Department of Earth Sciences, University of Manitoba, plans to publish, periodically, metallic and metallogenic maps of large areas of the world, based on the file. Further data items may be added to the file from time to time, to conform with new demands and new uses for MANIFILE.

REFERENCES

Aubouin, J.
1965: Geosynclines; Elsevier, Amsterdam - New York, 335 p.

Brisbin, W.C., and Ediger, N.M., Editors
1967: A national system for storage and retrieval of geological data in Canada; Nat. Adv. Comm. Res. Geol. Sci. (available from Geol. Survey Canada), 175 p.

Dickie, G.J., and Williams, G.D.
1972: Geologic features of oil and gas pools; Proc. 24th Inter. Geol. Congress, Section 16, p. 103-111.

Laznicka, P.
1970: Quantitative aspects in the distribution of base and precious metal deposits of the world; Ph.D. Thesis, University of Manitoba, 725 p.

Laznicka, P.
1973: Formation of nonferrous metal deposits in geological time; Can. Jour. Earth Sci. v. 10, p. 18-25.

Laznicka, P., and Wilson, H.D.B.
1972: The significance of a copper-lead line in metallogeny; Proc. 24th Inter. Geol. Congress, Section 4, p. 25-36.

Pamenter, C.B.
1971: What is the SAFRAS system?; Oilweek, v. 21, no. 50, p. 27-28.

Sutterlin, P.G., and De Plancke, J.
1969: Development of a flexible computer-processible file for the storage and retrieval of mineral deposits data; Proc. Symp. on Decision-Making in Mineral Expl. II, Feb. 1969, Univ. British Columbia, p. 11-42.

Williams, G.D., Dickie, G.J., and Steiner, J.
1972: Computer storage and retrieval of geologic data on coal deposits; Proc. First Geol. Conf. on Western Canadian Coal, Research Council of Alberta Info. Series No. 60, p. 73-84.

Wilson, H.D.B., and Laznicka, P.
1972: Copper belts, lead belts and copper-lead lines of the world; Proc. 24th Inter. Geol. Congress, Section 4, p. 37-51.