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FIELD DATA ACQUISITION METHODS FOR APPLIED GEOCHEMICAL SURVEYS AT THE GEOLOGICAL SURVEY OF CANADA

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FIELD DATA AQUISITION METHODS FOR APPLIED GEOCHEMICAL SURVEYS AT THE GEOLOGICAL SURVEY OF CANADA

ABSTRACT

The history of the development of field data cards as used in geochemical survey work by the Geochemistry Section of the Geological Survey of Canada is outlined. The development of the cards is closely linked to the development of computer methods as an aid to interpretation and the requirements for standardization in data acquisition.

A description of the field data cards currently in use is given together with the codes used in completing them.

RESUME

De façon générale, on donne l'historique de la mise au point de cartes de données sur le terrain qui sont utilisées pour les levés géochimiques effectués par la Section de géochimie de la Commission géologique du Canada. La mise au point de ces cartes est surtout motivée par les progrès accomplis dans les méthodes d'utilisation des ordinateurs qui facilitent l'interprétation et la nécessité de normaliser les données recueillies.

On donne une description des cartes de données sur le terrain courramment utilisées, de même que des codes utilisés pour les remplir.

INTRODUCTION

The advent of large scale regional geochemical reconnaissance programs has lead to the accumulation of enormous amounts of data. This volume of data necessitates that field notes and analytical results be acquired and stored systematically if anything but the most superficial interpretation of the data is to be carried out, and the data are to be more than ephemeral.

If a thorough interpretation of the data is to be undertaken certain parameters, relevant to the particular sampling media, must be observed and recorded in the field. If these parameters are to be consistently and rapidly recorded by many sampling crews it is necessary to formalize the note-taking. Hence the need for field cards and appropriate codes for use with them.

Sooner or later the volume of data, and the production time frame, will justify the use of computer technology. At this point in time the use of computer oriented field cards becomes mandatory. The level to which this technology will be applied will largely be a function of the interests and resources of the interpreting geochemist or geologist.

In the case of stream sediments such simple, but important, tasks as preparing lists of samples associated with the presence of precipitates or stains, or the presence of large amounts of organic material, can be rapidly undertaken. It becomes easy to check back to the field data for a sample exhibiting an interesting geochemistry and determine if any of the field parameters might be the cause of the sample's abnormality, rather than a primary geological phenomenon. Certainly the recording of catchment dominant rock-types has proved to be of the greatest assistance in establishing appropriate threshold levels through the inspection of histograms, etc. for each catchment group.

It is the task of the geochemist planning a sampling program to ensure that all the features which he considers might be of relevance in his interpretation are systematically recorded. The parameters specified on the Geological Survey field cards must not be considered exhaustive or the ultimate; they should, however, be regarded as a guide, or as in the most recently developed cards a minimum standard which must be maintained.

The systematic recording of sample point coordinates allows the rapid machine plotting of field observations or analytical results. In large surveys the time and cost saved on plotting by machine, rather than by hand, can alone justify the use of computer technology. However, once this stage has been reached only a small additional expenditure will allow a more thorough investigation of the data to whatever level is deemed expedient.

Finally, and possibly of greatest importance, the acquisition of field and analytical data in an organized fashion allows systematic storage. Thus the data have some continuing value past the immediate project and can be returned to, or compiled with other data, at a later time.

HISTORY OF FIELD CARD DEVELOPMENT

During the 1950's and early 1960's a number of regional geochemical surveys were carried out by the Geological Survey in the Yukon Territory and provinces of New Brunswick and Nova Scotia, Boyle et al. (1955, 1956, 1958), Holman (1963) and Smith (1960, 1963). During field work, notes were kept in standard notebooks; however, to ensure that all the relevant parameters were considered and recorded small cards were prepared as check lists for different materials.

In 1963 the Geological Survey commenced an investigation of biogeochemical methods which involved the systematic collection of a variety of materials. However, most materials collected were plant parts or soils; the field procedures used in this program have been described by Fortescue and Hornbrook (1967).

In 1964 Operation Keno was undertaken in the Keno Hill area of the Yukon Territory by C. F. Gleeson. This survey covered 1,900 square miles of mountainous terrain with some 5,900 stream and spring sediments being collected. To aid systematic field data acquisition Gleeson designed a field data card. The card was basically 5 by 8 inches, for easy filing, and had a perforated attachment punched so as to fit into a snap-on cover notebook. The card was double sided, field data being recorded on the front and analytical data on the back; it was divided so as to accommodate the data for four samples. The data were recorded across the card in columns; however, these columns were not divided in such a way as to directly use the card as a key punch input document for data transferral to an IBM 80 column punch card. Notwithstanding this, the data were transferred to punch cards for Gleeson by R. J. Bolton and G. J. Leaver of the Departmental Computer Centre, and some preliminary data processing was carried out.

From this first experience much was learned, and Gleeson, with the assistance of W. M. Tupper, designed the first specifically computer oriented field data card used by the Geochemistry Section. The new card still retained two features in common with its predecessor, namely: its final size and four sample capacity. This card has been described by Gleeson and Tupper (1967a, 1967b) and Boyle et al. (1966); it was 5 by 10 inches to fit into snap-on cover notebooks and had two parts. The bottom part was of a light weight card and had, as its Keno Hill predecessor, space for the results of analyses printed on the back. The top part was of a strong light paper and was separated from the bottom by a thin carbon paper. Alternate blocks of columns, relating to alternating data items, were screened with a light stipple to aid in filling in the correct columns. The base card copy and light top original were reduced to 5 by 8 inches by stripping off the binder tabs at both ends of the card; the original was then mailed to Ottawa for key punching.

The new field data card was used in the Operation Bathurst stream sediment survey during the summer of 1965. Although the field card was primarily meant for stream sediments it was also used for waters and rocks collected during this regional stream sediment survey.

During the winter of 1967 R. G. Garrett and A. Y. Smith greatly extended the range of field cards, devising cards for field analytical data, rocks, glacial materials and soils, stream sediments, and waters. These five cards were all essentially the same in design concept - size 5 by 8 inches to accommodate four samples per card. The first 31 columns of the field data cards are all identical, being reserved for sample number, Universal Transverse Mercator co-ordinates, and local bedrock type. The soil card uses the scheme of soil classification followed by the Department of Agriculture and adopted by Canadian soil scientists. This scheme is known as the Seventh Approximation and was published by the Canada Soil Survey Committee (1970). However, many geologists are more familiar with a system of soil horizon classification based on that used by the U. S. Department of Agriculture. To aid in comparison and coding, both soil horizon classification systems are described and coded. Additionally, a master identification code was included in the last column of the cards to facilitate rapid recognition of the type of data on the card.

Since 1967 only one change has been made to these five cards. During fieldwork in the Beaverlodge area in 1969, Dyck et al. (1971) collected both lake and stream sediments and waters. As a result of this experience the water and sediment cards were combined, and the basic set of field data cards was reduced to four. In effect the old sediment card was dropped, and the water card is now used for both sampling media with the sampler making the appropriate entry of the master identification code.

The next phase of development was brought about by the advent of large helicopter-supported lake sediment surveys in 1972. These surveys required that note-taking time be minimized, and to this end a check-off style card was devised by C. C. Durham after discussion with Geochemistry Section members. In using these cards a figure 1 is written in the appropriate predesignated column to indicate the presence of a particular phenomena or variety of a major feature. The card was designed in a general way for use with lake or stream sediments or waters. Certain new features were included at this time relevant to radon surveys where weather and water surface conditions are important. Because nearshore lake sediments were the main sampling medium, data were also recorded on the general nature of the lake bottom. Finally, an additional column was set aside to record if the sample was a duplicate of one previously collected. This card was used in the Bear-Slave lake sediment survey described by Allan et al. (1973).

During the winter of 1972 a contract lake sediment survey was undertaken in the Timmins, Kirkland Lake, Abitibi areas of northeastern Ontario and northwestern Quebec by C. F. Gleeson and Associates for the Geological Survey (Hornbrook and Gleeson, 1972). The samples were collected from the ice during winter and there was thus a limited set of features which could be identified and systematically recorded. To ensure that these were routinely recorded C. F. Gleeson and E. H. W. Hornbrook designed a simplified field data card that was successfully used on the survey.

Since 1972 the Geochemistry Section has participated in joint Federal-Provincial geochemical surveys and considerable experience in data recording has been gained from them. Because in future these surveys will be carried out by contract the cards have been considerably simplified in some respects. Two new field cards known as the 1974 revision have been implemented by R. G. Garrett and E. H. W. Hornbrook, these are for stream and spring sediments and waters, and for lake sediments. As with the 1972 revision of the lake sediment card, the new lake sediment card is in the check-off style to facilitate rapid note-taking in a helicopter. On these new cards such items as vegetation type, weather conditions, lake bottom type, water colour and temperature have been dropped. However, sufficient undefined columns are left on the cards to allow for the systematic recording of any of these items if they are applicable. The most important addition to the new cards is the replicate status field. During Federal-Provincial geochemical surveys, sites are routinely sampled in duplicate, samples are submitted for analysis in duplicate, and control (reference) samples are included in the batches submitted for analysis. These various types of replications occur randomly in blocks of twenty samples, thus only eighteen out of every twenty samples submitted for analysis are true field samples. The various replication samples are all submitted to the laboratory with numbers that belong to the project sequence, and it is, therefore, necessary to define on the field data card the nature of the sample which will be analyzed in terms of the sampling procedure. Using the replicate status codes the data are computer sorted into their various types and the necessary statistical tests are carried out to determine the sampling and analytical errors and long term comparability of the data.

The field cards, both laboratory and true field data types, have over the years been used in a variety of non-standard ways by Geochemistry Section members. These variations have been made to fit local and special problems. It is these modifications that have lead to the design of new field cards which are in some respects more general and in others more specific. The original cards were very general being used for all sampling media and their limitations were clear. The 1967 field cards attempted to overcome this by having different cards for each specific sample media and, with the exception of the rock card, many field data items were recorded for each media in predesignated columns. Experience has shown that in some cases the cards were still too general, e. g., that lake sediments had to be treated entirely separately from spring or stream sediments. On different surveys and projects the cards were also found to be too specific in their allocation of predesignated columns, i. e., certain data fields on the cards were irrelevant and others which were relevant were missing. The evolution has, therefore, been towards separate cards for specific sampling media, or groups of closely allied media, on which a minimum of columns are dedicated to the recording of what is by consensus within the Geochemistry Section regarded as a minimum acceptable data set. This ensures that the required data are easily collected, but also allows a maximum of flexibility from project to project. The future will no doubt see further modifications as our experience expands and we adapt to new sampling media and new environments.

IMPACT OF COMPUTER TECHNOLOGY ON FIELD CARD DESIGN

The most obvious impact of computer technology on field card design is the 80-column card format which allows immediate data transfer to punch cards. The use of various mnemonics and codes makes for efficient use of the available space. The codes, or those parts, most commonly used in a project, are soon committed to memory, and note-taking becomes rapid and consistent. One feature of the field data cards is the blank uncommitted space. This space is especially noticeable on the rock card and 1974 revision of the stream and spring sediment and water card where in excess of 20 columns are left free. The space serves two purposes. Firstly, it allows specific data to be coded into columns as defined by the project leader, a feature which makes the card flexible to the needs of both the project and the special interests of the project leader. Secondly, the space is available for free text notes using any convenient shorthand. Computer technology now allows the handling of free text and character string searches where the text can be scanned for specific words, mnemonics, or shorthand abbreviations.

In respect to the use of free text a further field card is being planned. This card will be almost entirely blank for free text notes, the only fixed format fields will be the sample number, a text type descriptor and card count suitable for such data base management systems as System 2000 or GDMS, and a master identification code. The free text card cannot be used alone as it contains no location or rock-type information; its purpose is to provide virtually unlimited additional free text capability to any of the field data cards. The efficient use of these cards will rely partly on the careful choice of the text type descriptors by the project leader. The proposed card is described in Appendix C.

FIELD CARDS CURRENTLY IN USE

Seven of the field cards are currently in use. These are the series of four 1967 cards for field laboratory, rock, glacial materials and soil, and sediment and water data; and the 1972 revision combined lake and stream sediment and water card, together with the 1974 revisions of the lake sediment card, and stream and spring sediment and water card. These seven cards are described in the next section. It appears possible that as less nearshore lake sediment surveys are carried out the 1972 revision of the lake and stream sediment and water card will pass into disuse; certainly the current tendency is towards sampling deep lake centre or bay sediments for which the 1974 revision lake sediment card was especially designed.

Whilst the 1974 revision cards will be used on contract surveys it is probable that the old more-detailed cards with many predesignated columns will continue to be used on orientation and follow-up surveys undertaken by the Geochemistry Section.

DESCRIPTION OF FIELD CARDS

All of the field data cards have certain features in common, the first 31 columns always contain the same information (e.g., Fig. 3). These items are sample number, UTM co-ordinate position, and rock-type. Additionally, the last column of the card, column 80, contains a master identification code which is used to indentify the general nature of the sample media.

One additional card is described which is used in field laboratories to record any analytical data generated. On this card only the sample number appears together with the last column master identification code.

The coding of the four common recording parameters is described:

Sample Number

The sample number is twelve characters long (columns 1-12) and divided into two equal six character parts. Columns 1-6 contain the number of the NTS map-sheet being used by the sampler. This may be either in 1: 50,000 or 1: 250,000 scale; in either case the alphabetic 1: 250,000 scale identifier is placed in column 4 of the first part, and in the case of 1: 250,000 scale maps columns 5 and 6 are left blank. The second part, columns 7-12, consists of a year number (7, 8), field party number (9), and ascending number (10-12) indicating how many samples have been collected by the sampler in the current year on the stated map-sheet.

106D04712056

The above number indicates that the sample was collected from within the area of NTS sheet 106D04 (Dublin Gulch in the Yukon Territory), the sample was collected in 1971 by field party number 2, and it was the 56th sample collected by them that year in map-area 106D04.

The difference between blank and zero can be important during computer compilation of the data. Therefore, a standard way of reporting the NTS map-sheet number has been adopted. As pointed out the 1: 250,000 level alphabetic character is always placed in column 4. The 1: 1,000,000 scale identification numerals, e.g., 106 are placed in columns 1 to 3. If the 1: 1,000,000 scale identifier has only two numerals, e.g., 24, these are placed in columns 2 and 3 with column 1 being left blank. When 1: 50,000 scale maps are used in the field the appropriate sheet identifier is always made up to 2 figures if the number is less than 10, e.g., 04, by placing a zero before the single digit. A few examples are given: -

106D04	(1: 50,000)
24A	(1: 250,000)
11F13	(1: 50,000)

The sample number may seen unnecessarily long; however, it has proved useful and to be no great problem in the field. The advantage of the number lies in its uniqueness and adaptability to computer oriented data compilation methods. The NTS map-sheet number allows easy compilation of either 1: 50,000 or 1: 250,000 scale geochemical maps. If geological bases are available on other scales, but to standard NTS boundaries, geochemical maps can as easily be produced at these scales. The year identifier eliminates confusion in multi-year projects within a single group of NTS map-sheets, and the field party number allows some quality control on sampling procedure and note-taking so that errors can be traced and extra training of the field personnel be undertaken. The last three digits, columns 9-12, revert to 001 as each new map-sheet is entered each year by each field party. This leads to consecutive numbers for each map-sheet and field party, thus facilitating the identification of missing samples and the reckoning of the total number of samples collected from any map-sheet.

The sample number can be unique over a period of one hundred years! -- by which time no doubt our present technology will be considered primitive and new technologies will have been developed making current ones redundant. This coupled with its information content has made it particularly useful to the Geochemistry Section. The one limitation, that yet has to be met, is if one field party in one year should collect more than 999 samples from one map-sheet. Ten field party identifiers are available and a new one can be used by the party in question. Certainly, it is considered unlikely that a Geological Survey of Canada project would lead to more than 9999 samples in a 1: 50,000 or 1: 250,000 map-sheet.

The sample number is broken down to two parts for recording on the sample bags. This is more convenient and since the bags are prenumbered for each day's work aids the rapid recognition of the map-sheet number, e.g.,: -

106D04
712056

This is particularly useful near map-sheet boundaries whilst sampling from a helicopter. In the worst case if sampling was being undertaken near a map-sheet corner the sampler would have four piles of prenumbered bags to choose from. With the bags prenumbered as described it is easy to take the next bag from the appropriate map-sheet pile.

Universal Transverse Mercator Co-ordinates

The majority of geochemical surveys are undertaken using, as a base, topographic maps of the National Topographic System, published by the Surveys and Mapping Branch of the Department of Energy, Mines and Resources.

In the Geochemistry Section all samples, or local sampling grids, are uniquely located in Canada using the UTM grid which is superimposed on all current 1: 50,000 and 1: 250,000 scale NTS maps. The general problems of the accuracy and precision of the location of points on these maps have been discussed by Kelly (1972) in relation to mineral deposits. With today's cartographic methods there is still an uncertainty of 0.5 mm in location; this is equivalent to 25 m and 125 m respectively at 1: 50,000 and 1: 250,000 scales. However, in applied regional geochemical studies absolute accuracy of position is not of prime importance. Of greater importance is the relocation of sample sites which requires good accuracy in the initial determination of the co-ordinates. Consequently, as much care as possible should be taken in marking the sample position on the map and in locating the sample position with reference to landmarks, etc.

The co-ordinates may be derived in one of two manners. Firstly, the position may be manually digitized using a celluloid, or other, roamer and the resulting co-ordinates entered on the field card. Using a celluloid roamer co-ordinates may be read to an accuracy of 10 or 100 metres respectively on 1: 50,000 and 1: 250,000 scale maps. These figures correspond

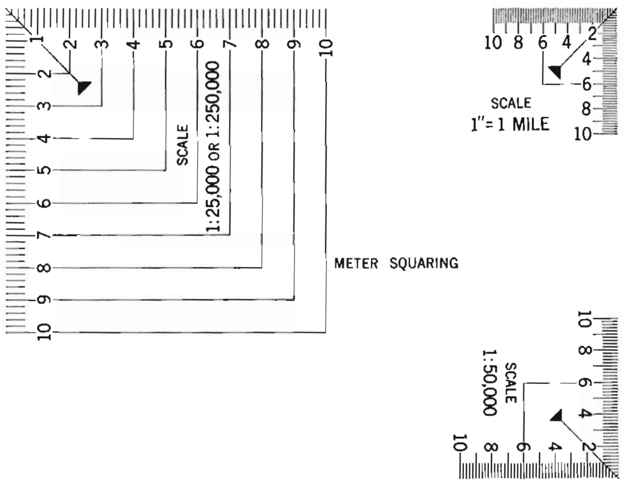


Figure 1. UTM Roamer (not to scale).

to half a division on the respective roamers and are within the absolute accuracy of the maps (Fig. 1). Secondly, the sample location map can be machine digitized, this will result in co-ordinates being generated to the nearest metre. The generated co-ordinates and associated sample numbers are stored on magnetic tape, punched paper tape, or cards and are later merged by computer with the remainder of the field data. In general, the precision of machine digitization is greater than can be obtained manually.

The choice of hand or machine digitizing will depend on the availability of digitizing equipment, the error rate for hand digitizing, the size of the project and other factors. Both techniques have been successfully employed at the Geological Survey of Canada. The full co-ordinate consists of three parts, the zone, the eastings and the northings. The UTM zone is a two digit number, columns 13-14, which for Canada is in the range of 07 to 22, corresponding to the Yukon Territory in the northwest and Newfoundland in the east. The UTM eastings are measured in metres and consist of six digits, columns 15-20. Each UTM zone is 6 degrees wide, and the central meridian of each zone has been given an easting of 500,000 metres. It follows, therefore, that the eastings decrease to the west of the central meridian and increase to the east of it. The UTM northings are recorded in metres to seven digits, columns 21-27, the actual figure corresponding to the distance north of the equator which has been given a zero northing.

Rock-type

The choice of rock-type to represent a catchment area will necessarily be somewhat subjective, as will the choice of underlying rock-type for soil and glacial material samples, if no outcrop is conveniently close at hand to confirm the information taken from the geological map. Both cases rely on previously made geological maps and are, therefore, subject to the well known vagaries of mapping. In the case of a rock sample the problems of rock nomenclature again arise; however, one would expect that within one project all samplers, as a result of the necessary joint discussions at the beginning of the project, would use similar nomenclature.

However subjective the choice and naming of rock-types may seem, the data are of great value; even if in an absolute sense a rock is slightly misnamed* it still belongs to a group of similar rocks. The rock-type is used as a sorting key to subdivide the data prior to routine statistical analysis to aid in the establishment of threshold levels for the different rock-types or materials derived from them.

A four-character mnemonic is employed to identify rock-types on the field cards. The mnemonics are similar to those used by the Geological Survey of Canada's Geodat system for chemical rock analysis management. Dawson (1970) has compiled an extensive list of material names and the mnemonics. A list of mnemonic rock names (Appendix A) has been generated using the modified Franklin method as described by Cohee (1967) and used by Dawson. The program which generated these mnemonics is also reproduced in Appendix A so that further mnemonics may be generated which conform with those already in use. The program is written in Fortran IV and runs at the Department of Energy, Mines and Resources' Computer Science Centre on a CDC 6400 under the Scope 3.4 operating system.

Master Identification Code

The Master Identification Code has been devised to facilitate rapid recognition of the nature of the data recorded on a punched card, either visually or by computer. The code is as follows:

1 Field laboratory analytical data
2 Rock field data
3 Glacial overburden field data
4 Soil field data
5 Stream, lake, or groundwater field data
6 Stream, spring, or lake sediment field data
9 Free text note card

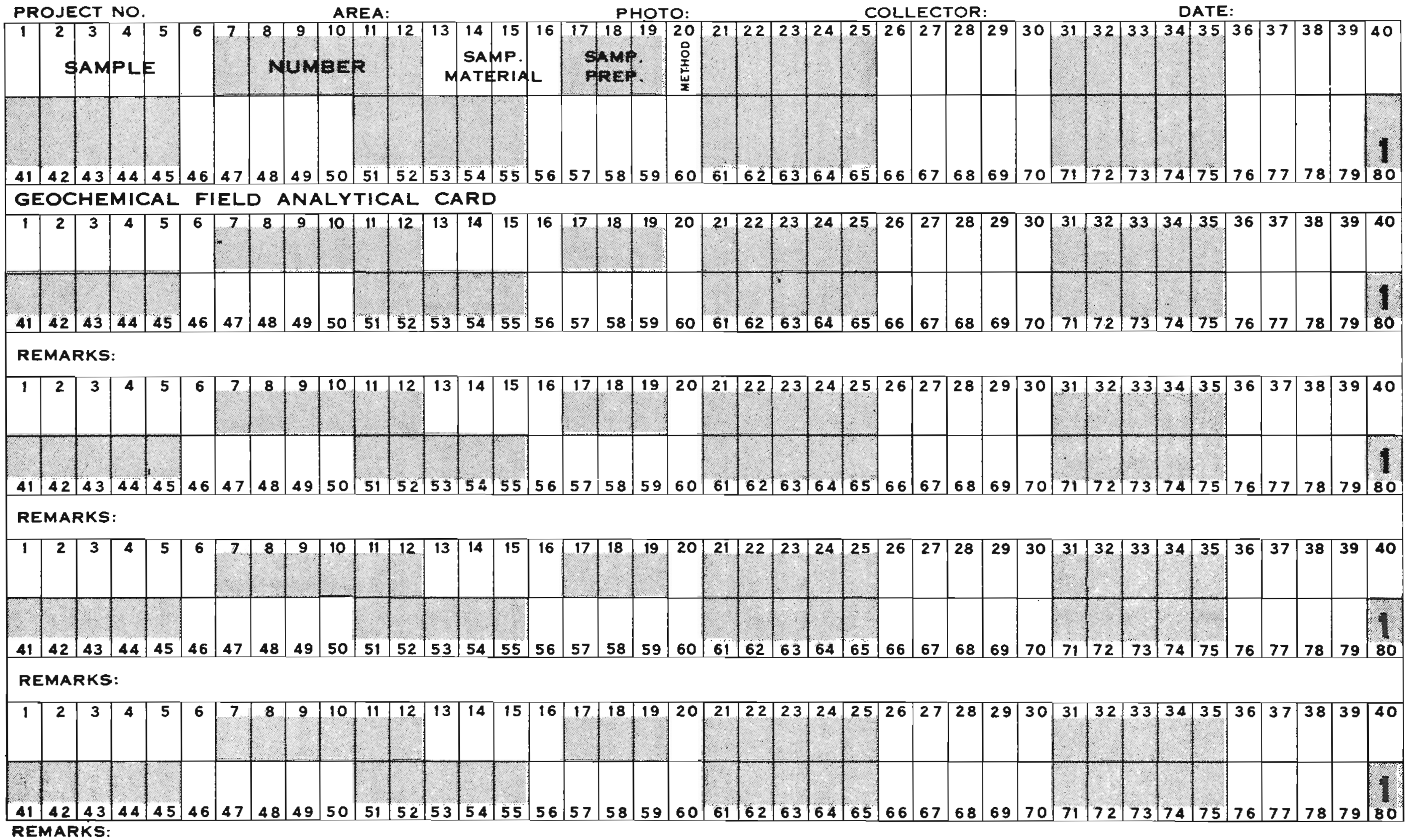
This Master Identification Code is employed on all the field cards except the 1972 revision of the combined water and sediment card used in early helicopter supported lake sediment surveys. Two further codes are utilized in the Geochemistry Section central laboratories in Ottawa:

7 Optical spectrography laboratory
8 Wet chemical laboratory

---

*This does not take into account gross misnaming, e.g., a granite for a gneiss or a hornfels for a basalt, which should not occur with trained personnel.

Figure 2. Geochemical field analytical card.



ANALYTICAL CARD
(see Fig. 2)

Column

1 - 6 NTS map-sheet part of Sample Number

7 - 12 Remainder of Sample Number

13 - 16 Sample Material: -

Rock	ROCK
Gossan	GSSN
Soil	SOIL
Undifferentiated glacial material	GLCM
Till (local)	TILL
Transported till (exotic)	TPDT
Glacial-lacustrine sediment	GSCM
Esker sediment	EKSM
Lake sediment	LKSM
Stream sediment	SMSM
Spring sediment	SPGS
Lake water	LKWR
Stream water	SRMW
Spring water	SPGW
Well water	WLWR
DDH water	DDHW
Heavy mineral	HVML

17 - 19 Sample Preparation Code. The first two columns indicate the maximum and minimum mechanical size of the fraction separated for analysis and the last column the maximum size of the material actually analyzed. The following codes are used: -

	ASTM	TYLER	OPENING, mm	ϕ, mm
1	5	5	4.00	-2.0
2	10	9	2.00	-1.0
3	18	16	1.00	0
4	35	32	.50	1.0
5	60	60	.25	2.0
6	80	80	.177	2.5
7	120	115	.125	3.0
8	230	250	.062	4.0

Zero is used to indicate all material finer than the preceding figure and is used in the second column: e.g., 606 -80 mesh fraction was separated and -80 mesh was the largest grain size analysed, or 457 -35 mesh +60 mesh fraction was ground to -120 mesh prior to analysis. A blank in the first two columns indicates a bulk sample but the maximum size fraction of the material submitted for analysis is still entered in the third column; e.g., 7 could indicate a rock ground to -120 mesh.

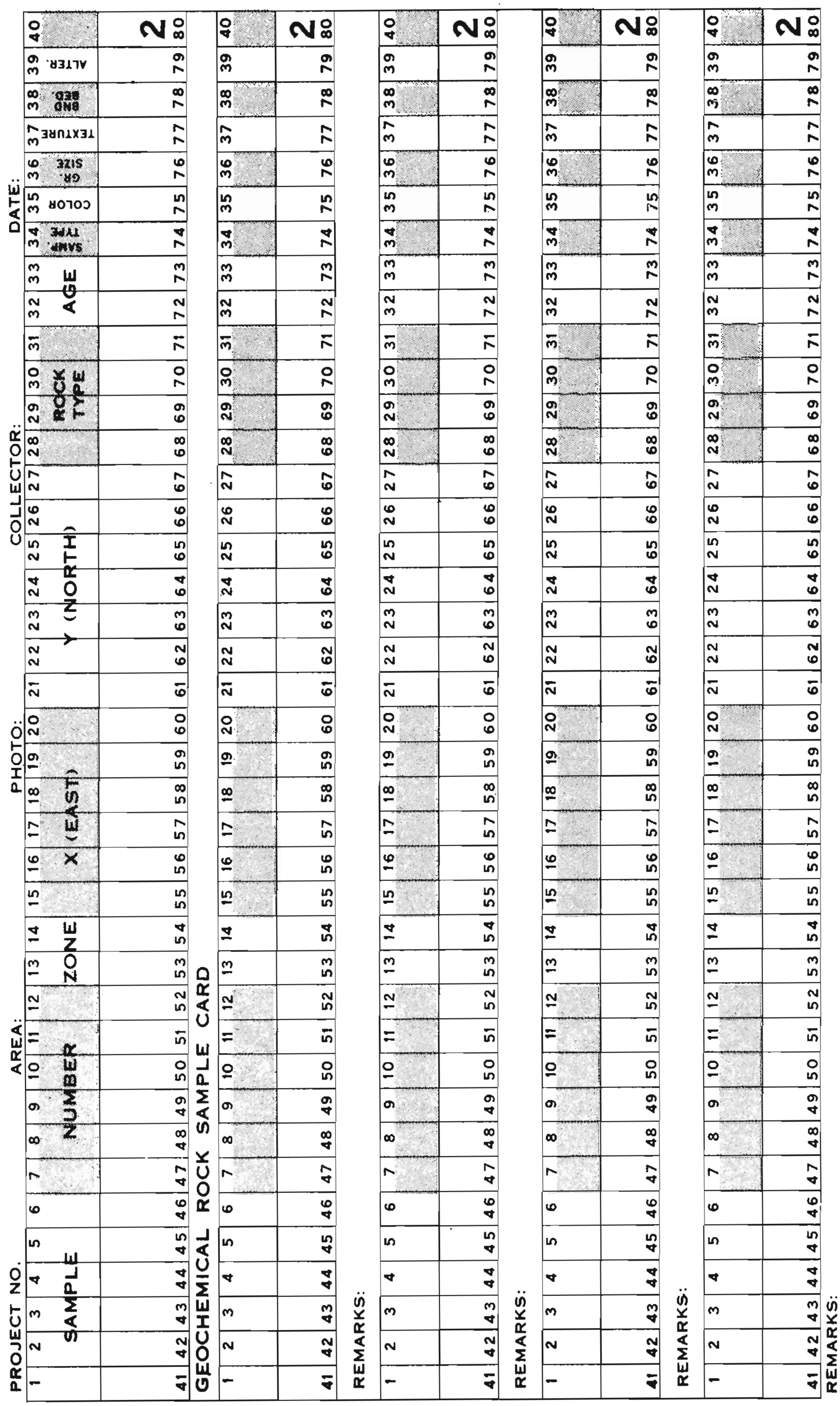
If all the fields are blank the Code is redundant, i.e., in the case of waters.

20 Method. A code established by the user if it is appropriate or needed.

21 - 25
26 - 30
31 - 35
etc.
Results of analyses in fields of five, eleven analyses may be recorded to five digits. A twelfth may be recorded to four digits.

80 1, the Master Identification code indicating a field analytical card.

Figure 3. Geochemical rock sample card.



ROCK CARD
(see Fig. 3)

Column

1 - 6 NTS map-sheet part of Sample Number

7 - 12 Remainder of Sample Number

13 - 14 UTM Zone

15 - 20 UTM Eastings

21 - 27 UTM Northings

28 - 31 Rock-type. The sampler's field name for the rock collected, the name is recorded as a four-character mnemonic, see Appendix A.

32 - 33 Age. A code is used to define the geological period of formation of the rock, Appendix B.

34 Sample Type. The source of the sample is described in a general manner: -

1 Single grab sample
2 Channel sample
3 Composite sample
4 Drill core
5 Talus or other transported boulder, etc.
6 Other

35 Colour: -

0	White	<20% Dark minerals
1	White and black	20-40%
2	White equals black	40-60%
3	Black and white	60-80%
4	Black	>80%
5	Grey	
6	Green	
7	Buff	
8	Orange or yellow	
9	Red or purple	

36 Grain Size. The grain size of the rock is described by a generalized scale which was chosen as a compromise for use with sedimentary, metamorphic and igneous rocks: -

0	<0.004 mm	Clay	glassy
1	0.004- 0.025 mm	Silt	aphanitic
2	0.025- 0.125 mm	very fine Sand	aphanitic
3	0.125- 0.250 mm	fine Sand	very fine grained
4	0.250- 0.50 mm	medium coarse Sand	very fine grained
5	0.50 - 1.00 mm	coarse Sand	fine grained
6	1.00 - 2.00 mm	very coarse Sand	medium grained
7	2.00 - 5.00 mm	Granules	medium grained
8	5.00 -20.0 mm	Pebbles	coarse grained
9	>20.0 mm	Cobbles, etc.	very coarse grained

37 Texture. The dominant textural feature of the rock is described: -

0 Uniform grain size
1 Variable grain size
2 Megacrystic
3 Pegmatitic
4 Miarolitic
5 Pyroclastic
6 Cataclastic
7 Bioclastic
8 Oolitic
9 Other

38 Banding or Bedding. The dominant banding or bedding features of the rock is described: -

0 Massive
1 Bedded
2 Crossbedded
3 Slump structured
4 Schistose or foliated
5 Gneissic banding
6 Migmatitic
7 Oriented megacrysts
8 Trachytic groundmass
9 Other

39 Alteration. Any supergene or hydrothermal alteration of the rock is described: -

0 Fresh
1 Weathered
2 Weathered, gossanous
3 Hydrothermal bleached white
4 Hydrothermal stained red or rusty

As discussed earlier the remainder of the card is user defined and will largely depend on the particular project, major rock-type of concern and the interests of the project leader.

As an example further fields are described for a granitoid rock sampling program carried out in the Yukon Territory.

40 Nature of the potash feldspars: -

0 Clear
1 Cloudy

41 Nature of the megacrysts (column 37 = 2): -

0 No megacrysts
1 Feldspar
2 Quartz
3 Quartz and feldspar
4 Metamorphic porphyroblasts
5 Other

42 - 43 Relative percentages of hornblende and biotite. The approximate colour index is recorded in column 35 and dark mineral information is expanded here. The sum of the two columns should be 9 using 0 = 0 - 10%, 5 = 51 - 60%, and 9 = 91 - 100%, etc.

e.g. 09 means <10% hornblende >91% biotite
27 means 21-30% hornblende 71-80% biotite
81 means 81-90% hornblende 11-20% biotite

44 Sulphide mineral occurrence: -

0 Absent
1 Present

45 - 49 Outcrop area. The approximate total outcrop area of the pluton being sampled is recorded to the nearest square kilometre.

50 - 54 Altitude. The sample site altitude above sea level is recorded from the sampler's NTS map or helicopter altimeter.

55 - 60 Pluton name. A six character mnemonic is given to each pluton sampled in order to facilitate subsequent computer processing of field and analytical data.

61 - 79 These columns are reserved for the sampler's shorthand notes on such features as texture or sulphide minerals. In the latter case a specific shorthand notation is used: -

PY	Pyrite
PO	Pyrrhotite
CP	Chalcopyrite
AS	Arsenopyrite
MO	Molybdenite
SP	Sphalerite
GA	Galena

80 2, the Master Identification Code indicating a rock sample card.

GLACIAL TILL AND SOIL CARD

(see Fig. 4)

Column	
1 - 6	NTS map-sheet part of Sample Number
7 - 12	Remainder of Sample Number
13 - 14	UTM Zone
15 - 20	UTM Eastings
21 - 27	UTM Northings
28 - 31	Rock-type. The underlying rock-type at the sample site is recorded as a four character mnemonic, see Appendix A.
32 - 36	Line. The line number of the sampling grid if samples are collected on a pre-surveyed local grid.
37 - 41	Station. The station number of the sample site on the sampling grid.
42 - 45	Slope. The slope of the ground at the sample site is recorded in two parts.

42-43 - Direction of slope, towards the direction, i.e.
N slopes away to north
SW slopes away to the southwest

44-45 - Magnitude of slope, to the nearest 5 degrees, i.e.
05 5°
25 25°

46 Relief. The slope is important in interpreting hydromorphic dispersion patterns. However, the general relief of the local environment is recorded: -

0 Flat
1 Low, 0-50 feet
2 Gentle, 50-200 feet
3 Moderate, 200-1000 feet
4 High, >1000 feet

47 - 48 Vegetation Type. This information is divided into two parts: -

47 -
0 No trees
1 Conifers
2 Deciduous
3 Mixed conifers and deciduous

48 -
M Moss
G Grass
L Labrador tea
S Spruce
N Pine
C Cedar
T Tamarak
P Poplar

48 - (cont'd)
H Hemlok
M Maple
B Birch
O Oak
A Alder
W Willow

The item chosen for column 48 is the dominant species.

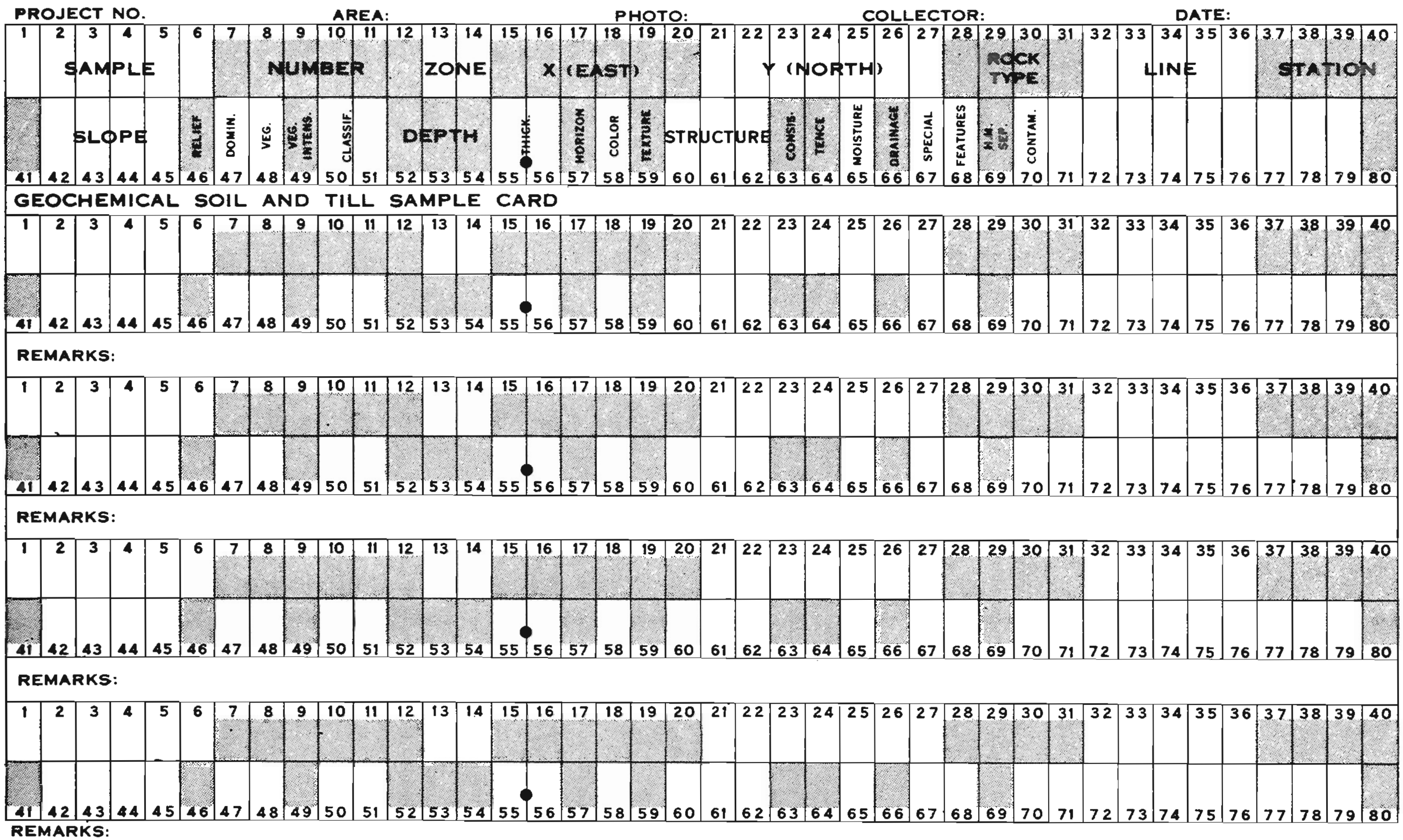
49 Vegetation Intensity: -

0 Open
1 Sparse
2 Moderate, Parkland
3 Well-wooded, Forest

50 - 51 Material Classification. The soil or glacial material sampled is given a broad classification: -

10	Chernozem -	undifferentiated
11		brown
12		dark brown
13		black
14		dark grey
20	Solonetyic -	undifferentiated
21		solonety
22		Solod
30	Podzolic -	undifferentiated
31		grey brown
32		dark grey wooded
33		grey wooded
34		humic Podzol
35		Podzol
40	Bremisolic -	undifferentiated
41		brown forest
42		brown wooded
43		acid brown wooded
44		acid brown forest
45		concretionary brown
46		alpine brown
50	Regosolic -	undifferentiated
51		Regosol
52		Podzo-Regosol
60	Gleysolic -	undifferentiated
61		humic Gleysol
62		Gleysol
63		eluviated Gleysol
70	Organic -	undifferentiated
71		Fibrisol
72		Mesisol
73		Humisol
80	Glacial -	undifferentiated
81		local till
82		transported till
83		glacial-lacustrine sediment
84		esker sediment

Figure 4. Geochemical soil and till sample card.



52 - 54 Depth. The depth to the top of the sample is recorded here. In the case of soils the depth is recorded to the nearest 1/10 of a foot, but the decimal point is not written, being implied between columns 53 and 54. This method is also used for most till sampling projects; however, if very deep samples are collected in a specific project the depths are recorded to the nearest foot.

55 - 56 Thickness. The sample thickness is recorded to the nearest 1/10 of a foot.

57 Soil Horizon. The soil horizon is recorded using a standard code, if the sample is of glacial material (column 50 = 8) this field is left blank: -

	United States	Canada
0	A_{00}	L or L-H
1	A_0	F
2	A_1	H or A_h
3	A_2	Ae
4	A_3	AB
5	B_1	BA
6	B_2	B_f or B_t
7	B_3	BC
8	C	C

58 The colour of the sample material is coded as follows: -

0 White
1 Buff
2 Yellow
3 Orange
4 Pink
5 Red
6 Brown
7 Dark Brown
8 Black
9 Grey

59 Texture. The general size classification and texture of the material is described here: -

0	<0.004 mm	fine Silt and Clay	clayey Soil
1	0.004-0.125 mm	Silt	clayey Loam
2	0.125-0.5 mm	fine Sand	Loam
3	0.5 -1.0 mm	medium Sand	sandy Loam
4	1.0 -2.0 mm	coarse Sand	sandy Soil
5	>2.0 mm	Granules etc.	

60 - 62 Structure. The structure of the material is described in three parts; grade, class and kind: -

60 - 1 Grade - weak
2 moderate
3 strong

61 - 1 Class - very fine
2 fine
3 medium
4 coarse
5 very coarse

62 - 1 Kind - single grain
2 massive
3 blocky, angular
4 blocky, subangular
5 blocky, granular
6 platey
7 prismatic

63 - 64 Consistence. The consistence of the sample is used to describe the aggregate nature of the sample and is dependent on the moisture content of the sample, see column 65: -

When sample is wet, column 65 = 1

11 Non sticky - non plastic
12 slightly plastic
13 plastic
14 very plastic

This is extended to slightly sticky, sticky and very sticky material

	non plastic	slightly plastic
non sticky	11	12
sllightly sticky	21	22
sticky	31	32
very sticky	41	42

	plastic	very plastic
non sticky	13	14
slightly sticky	23	24
sticky	33	34
very sticky	43	44

When sample is moist, column 65 = 2

51 non coherent
52 very friable
53 friable
54 firm
55 very firm

When sample is dry, column 65 = 3

61 loose
62 soft
63 slightly hard
64 hard
65 very hard
66 extremely hard
71 weakly cemented
72 strongly cemented
73 indurated

65 Moisture. The moisture content of the sample: -

1 Wet
2 Moist
3 Dry

66 Drainage. The internal drainage of the sample material is described here: -

1 Rapidly drained
2 Well drained
3 Moderately well drained

66 (cont'd)
4 Imperfectly drained
5 Poorly drained
6 Very poorly drained

67 - 68 Special Features. Certain special features of the sample or soil horizon may be described: - Accumulation of the following material in the sample

01 Lime
02 Iron
03 Clay
04 Silica
05 Manganese
06 Phosphate
07 Charcoal
08 Humus or organic mottling

The presence of pebbles or boulders in the profile

horizon	pebbles	boulders
A	10	15
B	11	16
C	12	17
A, B&C	13	18
B&C	14	19

Other features of interest

21 Disturbance, burried profile
22 Disturbance due to trenching
23 Road or track
24 Disturbance due to drilling activity
25 Animal burrow
26 Frozen ground

69 Heavy Mineral Separate: -

0 Bulk sample
1 Heavy mineral concentrate from sample

70 Contamination: -

0 None
1 Possible
2 Probable
3 Definite

71 - 79 User definable columns for notes or any systematic coded data of local applicability

80 A Master Identification Code indicating the general sample media: -

3 Glacial
4 Soil

Note: This card allows for sample location in terms of either UTM co-ordinates or some local grid. If the latter is used it is not necessary to record every point's UTM co-ordinate.
However, a minimum of two points must be recorded in terms of UTM co-ordinates. The following points are useful ones to choose: -

grid origin
the ends of the baseline
the four corners of each grid block

WATER AND SEDIMENT CARD
(see Fig. 5)

Column

1 - 6 NTS map-sheet part of Sample Number

7 - 12 Remainder of Sample Number

13 - 14 UTM Zone

15 - 20 UTM Eastings

21 - 27 UTM Northings

28 - 31 Rock-type. The major rock-type of the catchment area or hydrological system is recorded as a four character mnemonic, see Appendix A.

32 Sample Type. The type of material sampled is indicated: -

1 Stream sediment
2 Spring sediment
3 Heavy mineral concentrate
4 Stream water
5 Well, spring or DDH water
6 Lake sediment
7 Lake water

33 - 35 Stream Width or Lake Area. The stream width is recorded to the nearest foot or the lake area is recorded to the nearest 1/10 of a square kilometre. In this latter case the decimal point is not written but implied between columns 34 and 35.

36 - 38 Water Depth. The sampling depth is recorded to the nearest 1/10 of a foot, or 1/5 of a foot as is appropriate (0. 1' = 1. 2", 0. 2' = 2. 4", etc.).

39 - 40 Vegetation Type. This information is divided into two parts: -

39 - 0 No trees
1 Conifers
2 Deciduous
3 Mixed conifers and deciduous

40 - M Moss
G Grass
L Labrador Tea
S Spruce
N Pine
C Cedar
T Tamarak
P Poplar
H Hemlock
M Maple
B Birch
O Oak
A Alder
W Willow

The item chosen for column 40 is the dominant species.

41 Vegetation Intensity: -

0 Open
1 Sparse
2 Moderate, Parkland
3 Well-wooded, Forest

42 Relief. This is used to describe the general relief within the local sampling environment: -

0 Flat
1 Low, 0-50 feet
2 Gentle, 50-200 feet
3 Moderate, 200-1000 feet
4 High, >1000 feet

43 Soil Type. The general nature of the bank material is described here; -

1 Alluvial
2 Colluvial (bare rock, residual or mountain soils)
3 Glacial Till
4 Glacial outwash sediments

44 Water Level. The state of the water is described here in terms of normal carrying capacity: -

1 Dry
2 Low
3 Normal
4 High
5 Flood

45 Water Flow Rate: -

0 Stagnant
1 Slow
2 Moderate
3 Fast
4 Torrent

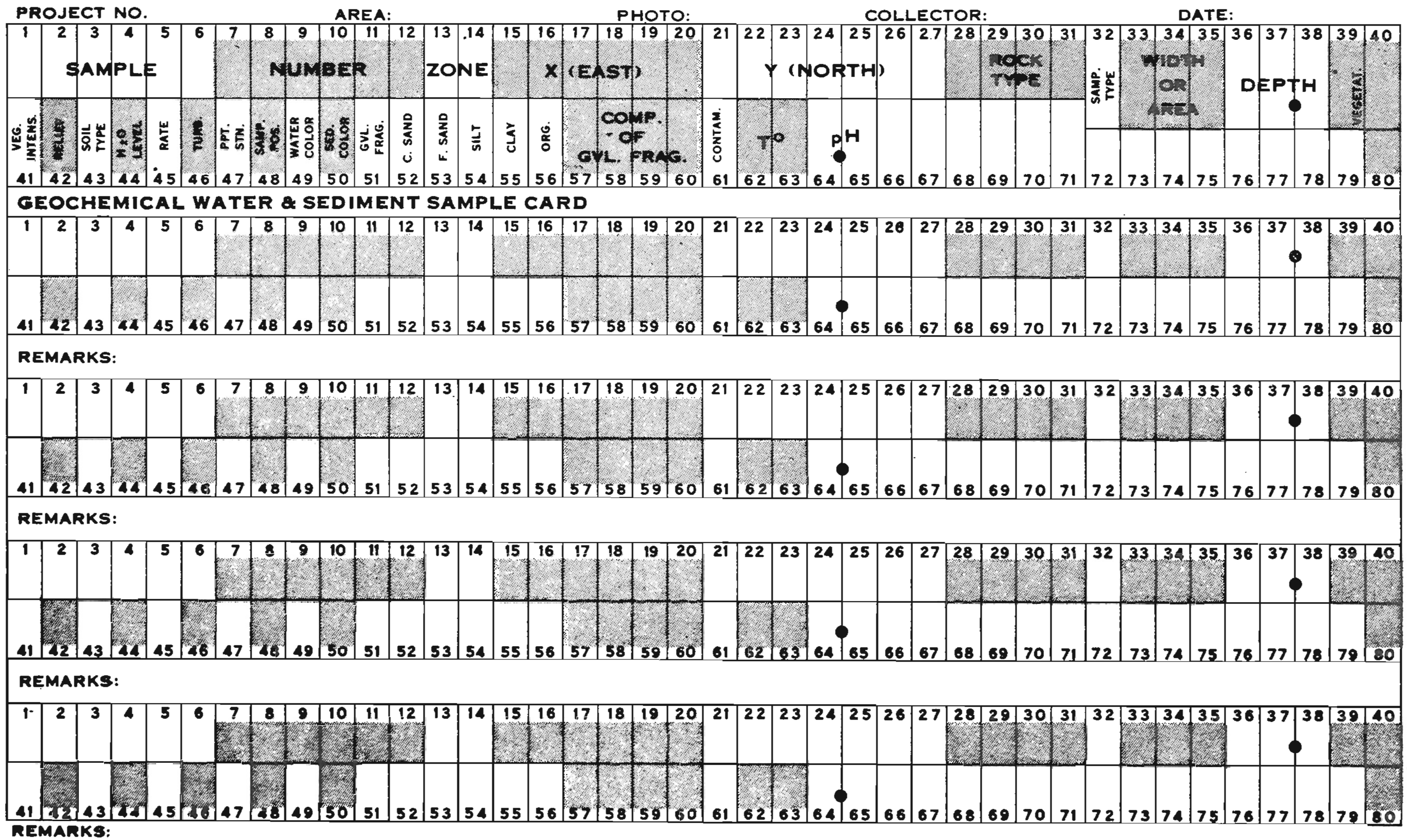
46 Water Turbulence: -

0 Still
1 Slight
2 Moderate
3 Strong

47 Precipitate or Stain. This refers to any coatings on pebbles, boulders or the stream bottoms: -

0 None
1 Fe hydroxides
2 Mn hydroxides
3 Organic slime
4 Lime
5 Sulphur

Figure 5. Geochemical water and sediment sample card.



48 Sample Position. The position of a stream sample is always defined looking downstream: -

- 0 Centre
- 1 Left side
- 2 Right side
- 3 Near lakeshore

49 Water Colour. This description by inference also includes information on the suspended load when reviewed in conjunction with Water Flow Rate (column 45) and Water Turbulence (column 46): -

- 0 Clear
- 1 White
- 2 Yellow
- 3 Orange
- 4 Red
- 5 Brown
- 6 Black

50 Sediment Colour: -

- 0 White
- 1 Buff
- 2 Yellow
- 3 Orange
- 4 Pink
- 5 Red
- 6 Brown
- 7 Dark Brown
- 8 Black
- 9 Grey

51 - 56 Bulk Stream Sediment Composition. The six fields are each used to describe a different size component on a scale of 0 to 9, the total of the columns should be 9. Thus each step indicates a 10% range, i.e., 0 = 0 - 10%, 5 = 51 - 60%, 9 = 91 - 100%.

51	>2 mm	Gravel and Cobbles
52	0.5 -2 mm	coarse Sand
53	0.125-0.5 mm	fine Sand
54	0.004-0.125 mm	Silt
55	<0.004 mm	Clay
56		Organics

57 - 60 Composition of gravel, fragments, etc. The rock-type of any clastic material is recorded here using the four character mnemonic code, see Appendix A.

61 Contamination: -

- 0 None
- 1 Possible
- 2 Probable
- 3 Definite

62 - 63 Water Temperature. Recorded to the nearest degree either Fahrenheit or Celsius.

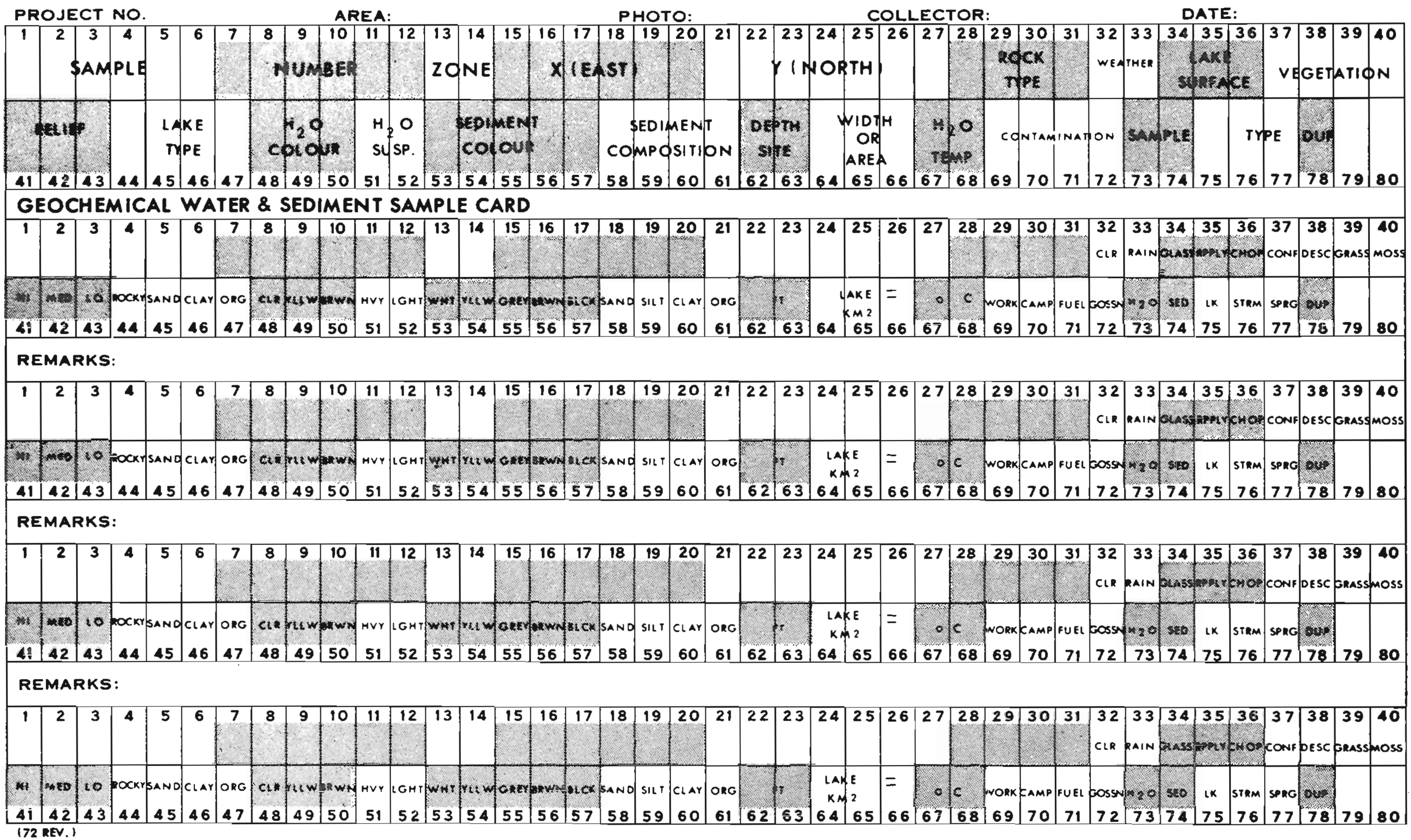
64 - 65 Water pH. Recorded to the nearest 1/10 pH unit with the decimal point implied between columns 64 and 65.

66 - 79 User definable columns for notes or any systematic coded data of local applicability.

80 A Master Identification Code indicating the general sample media: -

- 5 Water
- 6 Sediment

Figure 6. Geochemical water and sediment sample card (Rev. 72).



WATER AND SEDIMENT CARD (Rev. 72)

(see Fig. 6)

Column

1 - 6 NTS map-sheet part of Sample Number

7 - 12 Remainder of Sample Number

13 - 14 UTM Zone

15 - 20 UTM Eastings

21 - 27 UTM Northings

28 - 31 Rock-type. The major rock-type of the lake or stream catchment area is recorded as a four character mnemonic, see Appendix A.

32 - 33 Weather. The general weather conditions are recorded for the sample site: -

Clear or
Cloudy

34 - 36 Lake Surface. The water surface conditions are recorded for use in water dissolved gas studies: -

Glassy or
Rippled or
Choppy

37 - 40 Vegetation. The surrounding vegetation types are recorded, more than one may be checked: -

Conifers
Deciduous
Grasses
Moss

41 - 43 Relief. The general relief of the lake or stream catchment basin is recorded: -

High, shear steep elevations, or
Medium, gently rolling hills, or
Low, flat lying plain or tundra

44 - 47 Lake Type. The general nature of the lake, or stream bottom at the sample site is recorded: -

Rocky or
Sandy or
Clayey or
Organic, gyttja, etc.

48 - 50 Water Colour: -

Clear or
Yellow or
Brown

51 - 52 Suspended Matter. The suspended load in the water is noted as: -

Heavy or
Light

53 - 57 Sediment Colour. The colour of the sediment is noted when wet: -

White or
Yellow or
Grey or
Brown or
Black

58 - 61 Sediment Composition. The four columns are used to describe the bulk mechanical composition of the collected sediment on scales of 0 to 9, the total of the columns should be 9. Thus each step indicates a 10% range, i. e., 0 = 0 - 10%, 5 = 51 - 60%, and 9 = 91 - 100%, etc.: -

>0.5 mm	Sand, etc.
0.004-0.5 mm	Silt and fine Sand
<0.004 mm	Clay
	Organics

62 - 63 Water Depth. The sampling depth is recorded to the nearest foot.

64 - 66 Stream Width or Lake Area. The stream width is recorded to the nearest foot or the lake area is recorded to the nearest square kilometre.

67 - 68 Water Temperature. The temperature of the water at the sample site is recorded to the nearest degree Celsius.

69 - 72 Contamination. The presence of human or natural contamination on the lakeshore or close to the stream should be noted, more than one may be checked: -

Work site, trench, drill site, etc.
Camp site
Fuel cache
Gossan

73 - 74 Sample Medium: -

Water or
Sediment

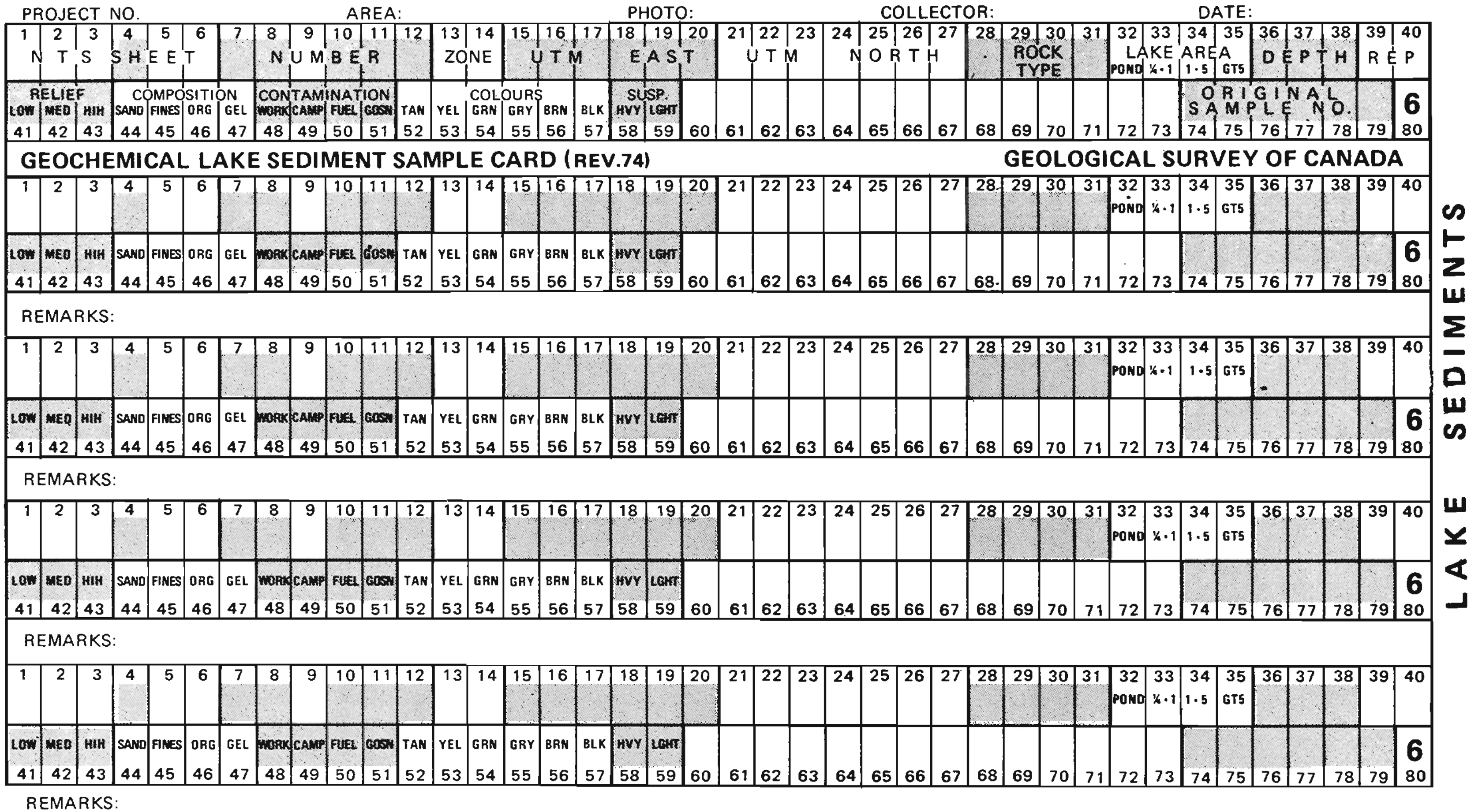
75 - 77 Sample Type. This is used to describe the source of the sample: -

Lake or
Stream or
Spring

78 Duplicate Status. Where a duplicate sample is collected a 1 is inserted in this field.

79 - 80 User defined columns for any systematically coded data.

Figure 7. Geochemical lake sediment sample card (Rev. 74).



LAKE SEDIMENT CARD (Rev. 74)

(see Fig. 7)

Column

1 - 6 NTS map-sheet part of Sample Number

7 - 12 Remainder of Sample Number

13 - 14 UTM Zone

15 - 20 UTM Eastings

21 - 27 UTM Northings

28 - 31 Rock-type. The major rock-type of the lake catchment area is recorded as a four character mnemonic, see Appendix A.

32 - 35 Lake Area. The area of the water body sampled is checked off by inserting a figure 1 in the appropriate column: -

Pond or
¼ - 1 sq. km. or
1 - 5 sq. km. or
>5 sq. km.

36 - 38 Water Depth. The sampling depth is recorded to the nearest foot.

39 - 40 Replicate Status. The relationship of the current sample to others in the project is described here in a two part code: -

39 - 0 A routine sample site
1 First of a duplicate pair
2 Second of a duplicate pair
3 Multilayer routine sample site
4 Routine spot later date resampling
5 Part of a multiple resampling set
6 Not designated
7 Not designated
8 Blind duplicate sample designation
9 Control (reference) sample designation

40 - 0 Single layer sediment
1 Top layer in a multilayered sediment
2 Second layer down
3 Third layer down
4 Sequence continues with layers numbered from the top down

Examples:
00 Routine regional nonlayered sample
10 First of a duplicate pair, nonlayered
20 Second of a duplicate pair, nonlayered
31 Top layer of a routine layered sample
32 Second layer of a routine layered sample
11 Top layer of the first of a duplicate pair

Examples: (cont'd)
12 Second layer of the first of a duplicate pair
41 Top layer of a resampling site
42 Second layer of a resampling site
80 Number (empty bag) for a blind duplicate cut of one of the previous 18 field samples
90 Number (empty bag) for a cut of a control (reference) sample

Note: - 3 in column 39 is used instead of 0, any other status 1-2 or 4-5 takes precedence. During any resampling, designated in column 39 by digits 4 or 5, the last part of the sample number (columns 7-12) of the original sample on the NTS map-sheet which caused the resampling is recorded in columns 74-79.

41 - 43 Relief. The general relief of the lake catchment basin is recorded: -

Low, flat lying plain or tundra, or
Medium, gently rolling hills, or
High, shear steep elevations

44 - 47 Composition. The four columns are used to describe the bulk mechanical composition of the collected sediment on scales of 0 to 3 and 0 or 1. The total of the first three columns must add to 3 or 4: -

0 Absent
1 Minor, <33%
2 Medium, 33-67%
3 Major, >67%

The three size fractions are divided as follows: -

44	>0.125 mm	Sand
45	<0.125 mm	Fines, Silt and Clay
46		Organics

The fourth column, 47, is used to record the presence of an organic gel or gyttja: -

0 Absent
1 Present

Examples: -
0220 No Sand, 33-67% Fines, 33-67% Organics, No Gel
0031 No sand, No Fines, >67% Organics, Gel like
0131 No Sand, <33% Fines, >67% Organics, Gel like

The first might represent an organic rich fine grained lake sediment; the second an organic rich gel centre lake bottom sediment and the last a generally similar sample containing some fines.

48 - 51 Contamination. The presence of human or natural contamination on, or near, the lakeshore should be noted, more than one may be checked: -

Work site, trench, drill site, etc.
Camp site
Fuel cache
Gossan

52 - 57 Sediment Colour. Up to two of the colours may be checked: -

Tan or
Yellow or
Green or
Grey or
Brown or
Black

58 - 59 Suspended Matter. The suspended load in the water is noted as: -

Heavy or
Light

The appropriate column is checked off or both are left blank if no suspension is visible.

60 - 73 User definable columns for notes or any systematic coded data of local applicability.

74 - 79 Original Sample Number. These columns are used in conjunction with the Replicate Status of the sample, see description of columns 39-40.

80 6, the Master Identification Code indicating a sediment card.

STREAM WATER AND SEDIMENT CARD (Rev. 74)

(see Fig. 8)

Column

1 - 6 NTS map-sheet part of Sample Number

7 - 12 Remainder of Sample Number

13 - 14 UTM Zone

15 - 20 UTM Eastings

21 - 27 UTM Northings

28 - 31 Rock-type. The major rock-type of the catchment area or hydrological system is recorded as a four character mnemonic, see Appendix A.

32 Sample Type. The type of material sampled is indicated: -

- 1 Stream Sediment
- 2 Spring Sediment
- 3 Heavy Mineral Concentrate
- 4 Stream Water
- 5 Well, Spring or DDH Water

33 - 35 Stream Width. The width of the stream at the sample site is recorded to the nearest foot.

36 - 38 Water Depth. The water depth is recorded to the nearest 1/10 of a foot, or 1/5 of a foot as is appropriate (0.1' = 1.2", 0.2' = 2.4", etc.).

39 - 40 Replicate Status. The relationship of the current sample to others in the project is described here in a two-part code: -

39 -
- 0 A routine sample site
- 1 First of a duplicate pair
- 2 Second of a duplicate pair
- 3 Multilayer routine sample site
- 4 Routine spot later date resampling
- 5 Part of a multiple resampling set
- 6 Not designated
- 7 Not designated
- 8 Blind duplicate sample designation
- 9 Control (reference sample) designation

40 -
- 0 Single layer sediment
- 1 Top layer in a multilayered sediment
- 2 Second layer down
- 3 Third layer down
- 4 Sequence continues with layers numbered from the top down

Examples:
- 00 Routine regional nonlayered sample
- 10 First of a duplicate pair, nonlayered
- 20 Second of a duplicate pair, nonlayered
- 31 Top layer of a routine layered sample
- 32 Second layer of a routine layered sample

Examples: (cont'd)
- 11 Top layer of the first of a duplicate pair
- 12 Second layer of the first of a duplicate pair
- 41 Top layer of a resampling site
- 42 Second layer of a resampling site
- 80 Number (empty bag) for a blind duplicate cut of one of the previous 18 field samples
- 90 Number (empty bag) for a cut of a control (reference) sample

Note: 3 in column 39 is used instead of 0, any other status 1-2 or 4-5 takes precedence. During any resampling, designated in column 39 by digits 4 or 5, the last part of the sample number (columns 7-12) of the original sample on the NTS map-sheet which caused the resampling is recorded in columns 74-79.

41 Contamination: -

- 0 None
- 1 Possible
- 2 Probable
- 3 Definite

42 Bank Type. The general nature of the bank material is described here: -

- 1 Alluvial
- 2 Colluvial (bare rock, residual or mountain soils)
- 3 Glacial till
- 4 Glacial outwash sediments

43 Colour. The general colour and suspended load of the water is noted: -

- 0 Clear
- 1 Brown transparent
- 2 White cloudy
- 3 Brown cloudy

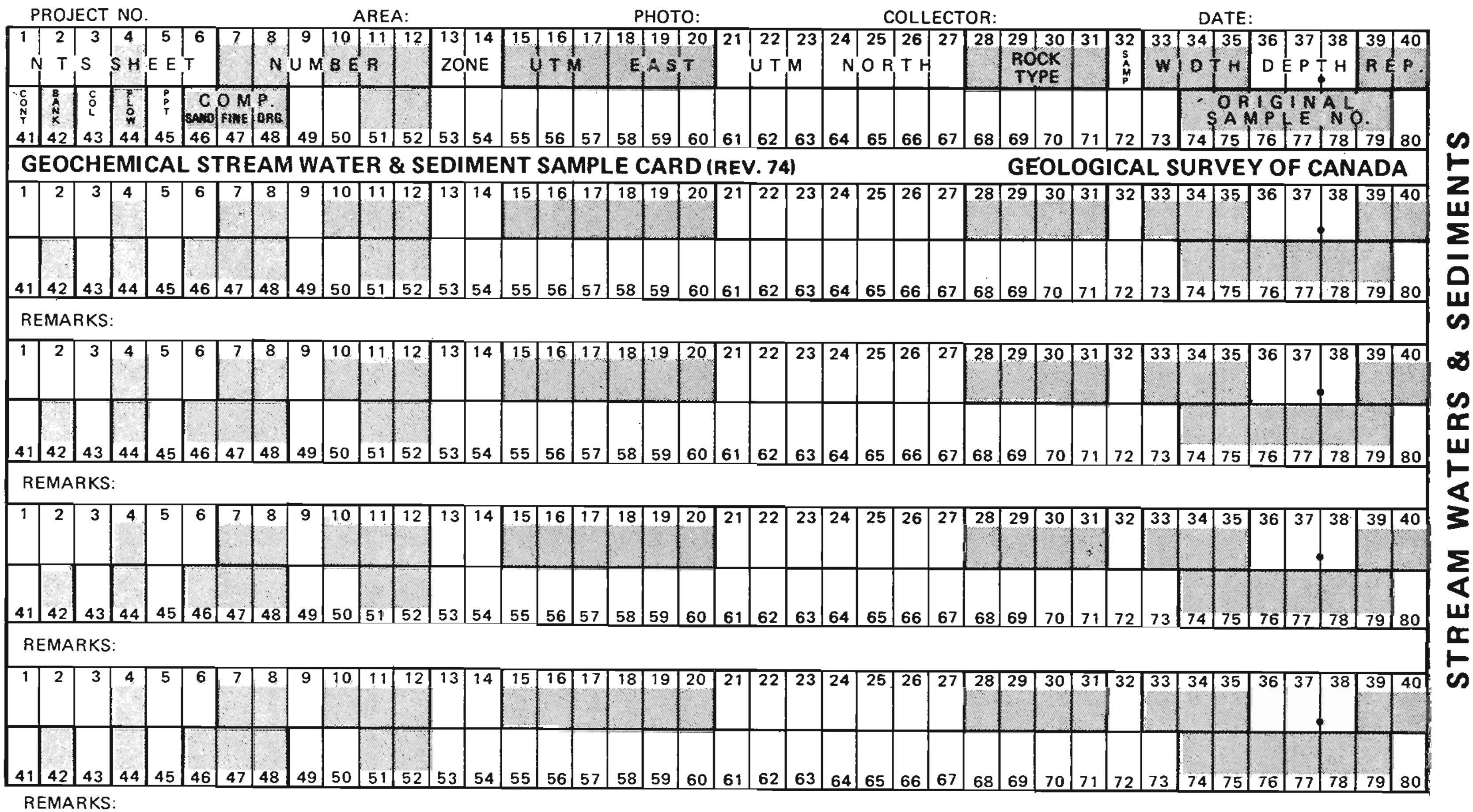
44 Water Flow Rate: -

- 0 Stagnant
- 1 Slow
- 2 Moderate
- 3 Fast
- 4 Torrent

45 Precipitate or Stain. The presence of any coatings on pebbles, boulders or stream bottoms is recorded: -

- 0 None
- 1 Red, brown or black
- 2 White or buff

Figure 8. Geochemical stream water and sediment sample card (Rev. 74).



46 - 48 Sediment Composition. The three columns are used to describe the bulk mechanical composition of the collected sample on scales of 0 to 3, the total of the columns must add to 3 or 4: -

- 0 Absent
- 1 Minor, <33%
- 2 Medium, 33-67%
- 3 Major, >67%

The size fractions are divided as follows: -

46	>0.125 mm	Sand
47	<0.125 mm	Fines, Silt and Clay
48		Organics

Examples: -
- 013 No Sand, <33% Fines, >67% Organics
- 121 <33% Sand, 33-67% Fines, <33% Organics
- 220 33-67% Sand, 33-67% Fines, No Organics
- 030 No Sand, >67% Fines, No Organics

The first might represent a muskeg sediment; the second a sample from a swampy stream section; and the third and fourth clean washed stream sediments.

49 - 73 User definable columns for notes or any systematic coded data of local or special applicability. The next two sets of two columns, 49-50 and 51-52, have been alternately screened to facilitate the recording of Temperature and pH. Temperature is recorded to the nearest degree Fahrenheit or Celsius and pH to the nearest 1/10 pH unit, the decimal point being implied between columns 51 and 52.

74 - 79 Original Sample Number. These columns are used in conjunction with the Replicate Status of the sample, see description of columns 39-40.

80 A Master Identification Code indicating general sample material: -

- 5 Water
- 6 Sediment

Acknowledgments

The field data and field laboratory cards described in this paper have developed over the years through the experience of past and present Geochemistry Section members and summer students who have worked on sampling crews. The present cards in use can in no way be looked upon as the invention of any one person, they have developed through a team effort of combined experience, frustration and needs.

The author would like to express his thanks to R.W. Boyle and E.H.W. Hornbrook who read the manuscript of this paper and suggested improvements to it.

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APPENDIX A

LIST OF MNEMONIC NAMES FOR SAMPLE MEDIA AND ROCKS

SRMW	STREAM◆WATER
LKWR	LAKE◆WATER
SPGW	SPRING◆WATER
WLWR	WELL◆WATER
DDHW	DIAMOND◆DRILL◆HOLE◆WATER
SMSM	STREAM◆SEDIMENT
LKSM	LAKE◆SEDIMENT
SPGS	SPRING◆SEDIMENT
HVML	HEAVY◆MINERAL
SOIL	SOIL
GLCM	GLACIAL◆MATERIAL
TILL	TILL I.E. LOCAL TILL
TPDT	TRANSPORTED◆TILL = EXOTIC TILL
GCSM	GLACIOLACUSTRINE◆SEDIMENT
EKSM	ESKER◆SEDIMENT
GSSN	GOSSAN
ROCK	ROCK
IGRK	IGNEOUS◆ROCK
ACIV	ACID◆INTRUSIVE
AEXV	ACID◆EXTRUSIVE
IMIV	INTERMEDIATE◆INTRUSIVE
IEXV	INTERMEDIATE◆EXTRUSIVE
BCIV	BASIC◆INTRUSIVE
BEXV	BASIC◆EXTRUSIVE
AKRK	ALKALIC◆ROCK
UMFC	ULTRAMAFIC
AGLM	AGGLOMERATE
ALSK	ALASKITE = LEUCOGRANITE
ALBT	ALBITITE
ALKB	ALKALI◆BASALT (C.F. HAWAIITE)
ALKG	ALKALI◆GRANITE
ALKS	ALKALI◆SYENITE (C.F. BOSTONITE)
AKDB	ALKALI◆DIABASE
ALNT	ALNOITE
ALMB	ALUMINOUS◆BASALT
ANDS	ANDESITE
AKRM	ANKARAMITE = AUGITE BASALT
ANRS	ANORTHOSITE
AGSN	AUGITE◆SYENITE
BSLT	BASALT
BSNT	BASANITE = OLIVINE TEPHRITE
BNTN	BENTONITE
BGRN	BIOTITE◆GRANITE
CMPN	CAMPTONITE
CRBN	CARBONATITE
CLPX	CLINOPYROXENITE
CRNN	CRINANITE
CLTF	CRYSTAL◆TUFF
DCIT	DACITE
DIBS	DIABASE
DORT	DIORITE
DLRT	DOLERITE
DUNT	DUNITE
ECLG	ECLOGITE
ESXT	ESSEXITE
FPPP	FELDSPAR◆PORPHYRY
FLST	FELSITE
FNIT	FENITE
FLBC	FLOW◆BRECCIA
GBBR	GABBRO
GLSS	GLASS
GRNT	GRANITE
GRDR	GRANODIORITE
GRPR	GRANOPHYRE
GRNS	GREENSTONE
HZBG	HARZBURGITE = SAXONITE
IJLT	IJOLITE
IGMB	IGNIMBRITE
JCPG	JACUPIRANGITE
KNLN	KENTALLENITE = MELANO-MONZONITE
KRPR	KERATOPHYRE
KRSN	KERSANTITE
KMBL	KIMBERLITE = MICA PERIDOTITE
LMPP	LAMPROPHYRE
LPTF	LAPILLI◆TUFF
LCTF	LITHIC◆TUFF
LGRT	LUGARITE
MLGN	MALIGNITE
MNTT	MINETTE
MNCQ	MONCHIQUITE = FOURCHITE
MNZN	MONZONITE = SYENODIORITE
MGRT	MUGEARITE
MCVG	MUSCOVITE◆GRANITE
NPLB	NEPHELINE◆BASALT
NPGB	NEPHELINE◆GABBRO
NPLS	NEPHELINE◆SYENITE = FOYAITE
NDMK	NORDMARKITE = QTZ ALKALI-SYENITE
NORT	NORITE
ODNT	ODINITE
OBCG	ORBICULAR◆GRANITE
OBSD	OBSIDIAN
OLVB	OLIVINE◆BASALT = PICRITE BSLT = OCEANITE
OLVD	OLIVINE◆DIORITE
OVDB	OLIVINE◆DIABASE
OVGB	OLIVINE◆GABBRO
OVNP	OLIVINE◆NEPHELINITE = NEPHELINE BASALT
OLVN	OLIVINE◆NORITE
ORPX	ORTHOPYROXENITE
OCTT	OUACHITITE
PRDT	PERIDOTITE
PRKN	PERKNITE
PNLT	PHONOLITE
PCRT	PICRITE
PLLV	PILLOW◆LAVA
PCSN	PITCHSTONE
PPBG	PORPHYROBLASTIC◆GRANITE
PCLC	PYROCLASTIC
PRXD	PYROXENE◆DIORITE
PRXN	PYROXENITE
QZBL	QUARTZ◆BASALT
QZDB	QUARTZ◆DIABASE
QRZD	QUARTZ◆DIORITE = TONALITE
QZFP	QUARTZ◆FELDSPAR◆PORPHYRY
QZGB	QUARTZ◆GABBRO
QZMZ	QUARTZ◆MONZONITE = ADAMELLITE
QRZN	QUARTZ◆NORITE
QZPP	QUARTZ◆PORPHYRY
RKVG	RAPAKIVI◆GRANITE
RDCT	RHYODACITE = QUARTZ-LATITE = DELLENITE
RYLT	RHYOLITE
RBKG	RIEBECKITE◆GRANITE
SCOR	SCORIA

SRPN	SERPENTINITE
SNKN	SHONKINITE
SDCG	SODIC◆GRANITE
SPSR	SPESSARTITE = MALCHITE
SPLT	SPILITE
SYNT	SYENITE
SGBR	SYENOGABBRO
TPHR	TEPHRA = VOLCANIC ASH
TPRT	TEPHRITE = FELDSPATHOIDAL BASALT
TSCN	TESCHENITE = ALKALI GABBRO
TRLT	THERALITE = NEPHELINE GABBRO
THLT	THOLEIITE
TLCB	THOLEIITIC◆BASALT
TRCD	TRACHYANDESITE = LATITE
TCBL	TRACHYBASALT
TRCT	TRACHYTE
TRCL	TROCTOLITE
TDJM	TRONDJHEMITE
TUFF	TUFF
VCTF	VITRIC◆TUFF
VGST	VOGESITE
VCCB	VOLCANIC◆BRECCIA
WDTF	WELDED◆TUFF
MPRK	METAMORPHIC◆ROCK
AMPB	AMPHIBOLITE
APBG	AMPHIBOLITE◆GNEISS
APBS	AMPHIBOLITE◆SCHIST
ACSC	ANDALUSITE◆CORDIERITE◆SCHIST
ADSC	ANDALUSITE◆SCHIST
AGGS	AUGEN◆GNEISS
BCGL	BASIC◆GRANULITE
BCSC	BASIC◆SCHIST
BGNS	BIOTITE◆GNEISS
BSCS	BIOTITE◆SCHIST
BCMB	BRUCITE◆MARBLE
CAPB	CALCAREOUS◆AMPHIBOLITE
CCGC	CALCAREOUS◆GREENSCHIST
CLCC	CALCSILICATE
CCCG	CALCSILICATE◆GNEISS
CRCK	CHARNOCKITE
CLSC	CHLORITE◆SCHIST
CARK	CORDIERITE◆ANTHOPHYLLITE◆ROCK
CDSC	CORDIERITE◆SCHIST
DPDG	DIOPSIDE◆GNEISS
DRGS	DIORITE◆GNEISS
GRSC	GARNET◆SCHIST
GRGS	GARNET◆GNEISS
GCPS	GLAUCOPHANE◆SCHIST
GNSS	GNEISS
GRNL	GRANULITE = LEPTITE
GRNG	GRANITE◆GNEISS
GRCS	GREENSCHIST
HBLD	HORNBLENDITE
HBDG	HORNBLENDE◆GNEISS
HBRG	HYBRID◆GNEISS
JDIT	JADEITE
LPLG	LITPARLIT◆GNEISS
MGGC	MAGNESIAN◆GREENSCHIST
MRBL	MARBLE
MARK	META◆ARKOSE
MDBS	META◆DIABASE
MTDR	META◆DIORITE
MGBR	META◆GABBRO
MGCK	META◆GREYWACKE
MSDM	META◆SEDIMENT
MVCC	META◆VOLCANIC
MCSC	MICA◆SCHIST
MGMT	MIGMATITE
MCVS	MUSCOVITE◆SCHIST
NPLG	NEPHELINE◆GNEISS
ORGS	ORTHOGNEISS
PRGS	PARAGNEISS
PCSC	PELITIC◆SCHIST
PLLT	PHYLLITE
QZSS	QUARTZ◆SERICITE◆SCHIST
QSBS	QUARTZ◆SERICITE◆BIOTITE◆SCHIST
SCST	SCHIST
SCSC	SERICITE◆SCHIST
SLMG	SILLIMANITE◆GNEISS
SLTE	SLATE
SPSN	SOAPSTONE
SLSC	STAUROLITE◆SCHIST
SPCS	SULPHIDIC◆SCHIST
TCSC	TALC◆SCHIST
HRFL	HORNFELS
ADHF	ADALUSITE◆HORNFELS (C.F. CHIASTOLITE)
BCHF	BASIC◆HORNFELS
CCHF	CALCSILICATE◆HORNFELS = SKARN = TACTITE
CDHF	CORDIERITE◆HORNFELS
SKRN	SKARN
SPSC	SPOTTED◆SCHIST
SPDS	SPOTTED◆SLATE
CCLS	CATACLASITE
BRCC	BRECCIA
GOUG	GOUGE
MLNT	MYLONITE
PLNT	PHYLLONITE
SMRK	SEDIMENTARY◆ROCK
ANDR	ANHYDRITE
ARNT	ARENITE = PSAMMITE = SANDSTONE
ACSL	ARENACEOUS◆SHALE
ARGL	ARGILLITE
AGCL	ARGILLACEOUS◆LIMESTONE
AGCS	ARGILLACEOUS◆SANDSTONE
ARKS	ARKOSE = ARKOSIC ARENITE
BCSL	BENTONITIC◆SHALE
BMSD	BITUMINOUS◆SANDSTONE = TAR SAND
BMSL	BITUMINOUS◆SHALE = OIL SHALE
BCKS	BLACK◆SHALE
CLCR	CALCARENITE
CLCS	CALCAREOUS◆SHALE
CLCD	CALCIRUDITE
CBCS	CARBONACEOUS◆SHALE
CHRT	CHERT
CIFM	CHERT◆IRON◆FORMATION = TACONITE
CRLM	CHERT◆LIMESTONE
CLAY	CLAY
CLIR	CLAY◆IRONSTONE
COAL	COAL
CGLM	CONGLOMERATE
DTMT	DIATOMITE
DLMT	DOLOMITE = DOLOSTONE
DMLM	DOLOMITIC◆LIMESTONE
EVPR	EVAPORITE
FPCA	FELDSPATHIC◆ARENITE (INCLUDES ARKOSE)
FPGK	FELDSPATHIC◆GRAYWACKE
FPWK	FELDSPATHIC◆WACKE
GRCK	GRAYWACKE
GRSD	GREENSAND
GPSM	GYPSUM
HLIT	HALITE
IRFM	IRON◆FORMATION
JPRD	JASPEROID
LGNT	LIGNITE
LMSN	LIMESTONE = CALCILUTITE
LMDM	LIMEY◆DOLOMITE = CALC-DOLOMITE
LCAR	LITHIC◆ARENITE
LCGK	LITHIC◆GRAYWACKE

```
LCWK  LITHIC*WACKE
MARL  MARL
MDSN  MUDSTONE = CLAYSTONE
NVCL  NOVACULITE
OGCG  OLIGOMICTIC*CONGLOMERATE
ORQZ  ORTHOQUARTZITE
PLIT  PELITE = LUTITE
PSPR  PHOSPHORITE
PRCL  PORCELLANITE
PMCG  POLYMICTIC*CONGLOMERATE
QRTZ  QUARTZITE
QZZS  QUARTZOZE*SHALE
RUDT  RUDITE = PSEPHITE
SNDS  SANDSTONE
SPPL  SAPROPEL
SLCS  SELENITIC*SHALE
SHLE  SHALE
SLSN  SILTSTONE
SMDM  STROMATOLITIC*DOLOMITE
SBGK  SUBGRAYWACKE
TLLT  TILLITE
TRVR  TRAVERTINE
WCKE  WACKE = IMPURE ARENITE
MRLZ  MINERALIZATION
MVSP  MASSIVE*SULPHIDE
SCKK  STOCKWORK
VEIN  VEIN
ALRZ  ALTERATION*ZONE
CNSN  CHINA*STONE
GRSN  GREISEN
```

LISTING OF COMPUTER PROGRAM FOR GENERATING MNEMONICS

```
      PROGRAM MNMNC(INPUT,OUTPUT,TAPE1=INPUT,TAPE2,TAPE3=OUTPUT)
C
C     GEOCHEMISTRY SECTION, GEOLOGICAL SURVEY OF CANADA, OTTAWA
C
C     PROGRAM TO GENERATE VARIABLE LENGTH MNEMONIC CODES.
C
C     THE BASIC ALGORITHM IS KNOWN AS THE MODIFIED FRANKLIN METHOD AND
C     HAS BEEN DESCRIBED BY COHEE (A.A.P.G. BULL. 1967, V51, P1047-50)
C     THIS METHOD HAS FURTHER BEEN MODIFIED TO COVER NUMERALS, WHICH ARE
C     INCORPORATED AS FOUND IN THE INPUT INTO THE FINAL MNEMONIC.
C
C     INPUT WORDS ARE PUNCHED LEFT JUSTIFIED ACROSS INDIVIDUAL DATA
C     CARDS AND MAY BE UP TO 40 CHARACTERS LONG.  HYPHENS AND INTER-WORD
C     GAPS ARE REPLACED BY ASTERISKS.  THE MNEMONIC MAY HAVE UP TO EIGHT
C     CHARACTERS, DEFINED BY NCHR AT THE START OF THE PROGRAM.  THE
C     INPUT WORD(S) MUST NOT CONTAIN MORE THAN NCHR-1 ASTERISKS, I.E.
C     HAVE MORE WORD-PARTS THAN THE LENGTH OF THE MNEMONIC.  IF NUMERALS
C     ARE INCLUDED (IAST+INMB) MUST BE .LE. NCHR.  UP TO 1000 INPUT
C     DATA CARDS MAY BE STACKED SEQUENTIALLY, THE LAST CARD IS FOLLOWED
C     BY A SLASH CARD, I.E. / PUNCHED IN COLUMN 1.
C
C     PROGRAM WRITTEN IN FORTRAN 4 FOR CDC 6400 (SCOPE 3.4) BY GARRETT
C     IN OCTOBER, 1973.  BASED ON AN ORIGINAL CDC 3100 PROGRAM WRITTEN
C     AS GSC PROGRAM C60308.
C     PROGRAM EXTENSIVELY MODIFIED, JUNE 1974.
C
      DIMENSION NAME(40),SAME(40),IDIG(40),CHAR(27),NUMB(10)
      DIMENSION SAVE(8,1000)
      COMMON /A/NAME,SAME,IDIG,AST,BLK,CHAR,NCHR,MCHR,LEND
      COMMON /S/SAVE,NRCD,ISAV,IAST,NS,M
      INTEGER SAME,CHAR,AST,BLK,SAVE
C
      DATA (CHAR=1HA,1HE,1HI,1HO,1HU,1HW,1HH,1HY,1H ,1HT,1HN,1HS,1HR,1HL
     1           ,1HD,1HC,1HM,1HF,1HG,1HP,1HK,1HB,1HV,1HX,1HJ,1HQ,1HZ)
      DATA (NUMB=1H0,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9)
      DATA (IEND=1H/),(AST=1H*),(BLK=1H ),(M=1)
C
C     DEFINE NUMBER OF LETTERS FOR MNEMONIC AND INITIALIZE
      NCHR=4
      IF(NCHR.GT.8)NCHR=8
      NAST=NCHR-1
      LEND=4-NCHR/2
      MCHR=2*NCHR-2
      NRCD=NS=0
      WRITE (3,101)
      REWIND 2
```

```
C
C      READ INPUT WORD AND CHECK FOR END OF RUN
     1 READ (1,102) NAME
       IF(NAME(1).EQ.IEND)GO TO 13
C
C      INITIALIZE FOR THIS MNEMONIC
       ICHR=IAST=INMB=0
       DO 2 I=1,40
       IDIG(I)=I
     2 SAME(I)=NAME(I)
C
C      VERIFY THE INPUT WORD AND MAKE A COUNT FOR EACH CHARACTER TYPE
       DO 6 I=1,40
       IF(NAME(I).EQ.BLK)GO TO 7
       DO 3 J=1,27
       IF(NAME(I).NE.CHAR(J))GO TO 3
       ICHR=ICHR+1
       GO TO 6
     3 CONTINUE
       IF(NAME(I).NE.AST)GO TO 4
       IAST=IAST+1
       GO TO 6
     4 DO 5 J=1,10
       IF(NAME(I).NE.NUMB(J))GO TO 5
       INMB=INMB+1
       GO TO 6
     5 CONTINUE
       IERR=2
       GO TO 9
     6 CONTINUE
     7 ICHR=ICHR+INMB
       ISAV=ICHR
C
C      USE THE ORIGINAL WORD IF IT IS .LE. NCHR CHARACTERS
       IF(ICHR.GT.NCHR)GO TO 8
       CALL REMOV
       GO TO 12
C
C      CHECK FOR THE NUMBER OF ASTERISKS AND ANY OTHER ERRORS
     8 IERR=1
       IF((IAST+INMB).GT.NCHR)GO TO 9
       IF(NAST-IAST)9,10,11
     9 IF(MOD(M,40).EQ.0)WRITE (3,102)
       IF(IERR.EQ.1)WRITE (3,103) NAME
       IF(IERR.EQ.2)WRITE (3,104) NAME
       M=M+2
       GO TO 1
C
C      FORM MNEMONIC
    10 CALL QUICK
       GO TO 12
    11 CALL SHORT(ICHR,IAST)
C
C      PRINT WARNING IF ALL 40 CHARACTERS OF THE INPUT WORD WERE USED
    12 IF((ISAV+IAST).GE.40)WRITE (3,105) SAME
C
C      STORE MNEMONIC AND ORIGINAL WORD AFTER CHECKING FOR DUPLICATIONS
       NRCD=NRCD+1
       CALL STORE
       GO TO 1
C
C      PRINT FINAL MNEMONIC LIST
    13 CALL PRINT(NRCD)
       STOP
C
   102 FORMAT (40A1)
```

```
  101 FORMAT (1H1,32X,26H* LIST OF ERROR MESSAGES *//)
  103 FORMAT (1H ,32X,27HTOO MANY WORD-PARTS IN --- ,40A1/)
  104 FORMAT (1H ,32X,27HFORBIDDEN CHARACTER IN --- ,40A1/)
  105 FORMAT (1H ,32X,27H40 CHARACTERS FOUND IN --- ,40A1/)
C
      END


      SUBROUTINE REMOV
C
      DIMENSION NAME(40),IDUM(80),JDUM(28)
      COMMON /A/NAME,IDUM,AST,JDUM,NCHR,MCHR
      INTEGER AST
C
C     REMOVE ANY ASTERISKS FROM MNEMONIC
      J=1
      DO 1 I=1,MCHR
      IF(NAME(I).EQ.AST)GO TO 1
      NAME(J)=NAME(I)
      IF(J.EQ.NCHR)GO TO 2
      J=J+1
    1 CONTINUE
C
C     PAD OUT RIGHT HAND END OF MNEMONIC WITH BLANKS
    2 CALL PADER
      RETURN
C
      END


      SUBROUTINE PADER
C
      DIMENSION NAME(40),IDUM(81),JDUM(27)
      COMMON /A/NAME,IDUM,BLK,JDUM,NCHR
      INTEGER BLK
C
C     PAD OUT RIGHT HAND END OF MNEMONIC WITH BLANKS
      IF(NCHR.EQ.8)RETURN
      NCHRP1=NCHR+1
      DO 1 I=NCHRP1,8
    1 NAME(I)=BLK
      RETURN
C
      END


      SUBROUTINE QUICK
C
      DIMENSION NAME(40),IDUM(80),JDUM(28)
      COMMON /A/NAME,IDUM,AST,JDUM,NCHR
      INTEGER AST
C
C     FORM MNEMONIC FROM FIRST CHARACTER OF EACH WORD-PART
      J=2
      DO 1 I=2,40
      IF(NAME(I).NE.AST)GO TO 1
      NAME(J)=NAME(I+1)
      IF(J.EQ.NCHR)GO TO 2
      J=J+1
    1 CONTINUE
C
C     PAD OUT RIGHT HAND END OF MNEMONIC WITH BLANKS
    2 CALL PADER
      RETURN
C
      END


      SUBROUTINE SHORT(ICHR,IAST)
```

```
C
      DIMENSION NAME(40),IDUM(40),IDIG(40),CHAR(27)
      COMMON /A/NAME,IDUM,IDIG,AST,BLK,CHAR,NCHR
      INTEGER AST,BLK,CHAR
C
C     COMMENCE GENERATING MNEMONIC, SCANNING FOR CHARACTERS 1 TO 8
      J1=1
      J2=8
    1 DO 3 J=J1,J2
      IWDL=ICHR+IAST
      IWDLM1=IWDL-1
      DO 2 II=1,IWDLM1
      I=IWDL+1-II
      IF(NAME(I).NE.CHAR(J))GO TO 2
      IF(NAME(I-1).EQ.AST)GO TO 2
      CALL SHIFT(I,ICHR,IWDL)
      IF(ICHR.LE.NCHR)GO TO 5
    2 CONTINUE
    3 CONTINUE
C
C     CHECK FOR AND ELIMINATE DOUBLE LETTERS
      IWDL=ICHR+IAST
      DO 4 II=1,IWDL
      I=IWDL+1-II
      IM1=I-1
      IF(NAME(I).NE.NAME(IM1))GO TO 4
      IF((IDIG(I)-IDIG(IM1)-1).NE.0)GO TO 4
      CALL SHIFT(I,ICHR,IWDL)
      IF(ICHR.LE.NCHR)GO TO 5
    4 CONTINUE
C
C     RESET J1 AND J2 TO SCAN CHARACTERS 10 TO 27
      J1=10
      J2=27
      GO TO 1
C
C     REMOVE ANY ASTERISKS AND BLANK PAD RIGHT HAND END OF THE MNEMONIC
    5 CALL REMOV
      RETURN
C
      END


      SUBROUTINE SHIFT(I,ICHR,IWDL)
C
      DIMENSION NAME(40),IDUM(40),IDIG(40)
      COMMON /A/NAME,IDUM,IDIG
C
C     CONDENSE MNEMONIC ONE CHARACTER LEFTWARDS
      IWDLM1=IWDL-1
      DO 1 K=I,IWDLM1
      KP1=K+1
      IDIG(K)=IDIG(KP1)
    1 NAME(K)=NAME(KP1)
      ICHR=ICHR-1
      RETURN
C
      END


      SUBROUTINE STORE
C
      DIMENSION NAME(40),SAME(40),IDIG(40),IDUM(27),TEMP(8),SAVE(8,1000)
      COMMON /A/NAME,SAME,IDIG,AST,BLK,IDUM,NCHR,MCHR,LEND
      COMMON /S/SAVE,NRCD
      INTEGER SAME,AST,BLK,FLAG,TEMP,SAVE
C
C     CHECK TO SEE IF THIS MNEMONIC HAS BEEN GENERATED ALREADY
      NN=NRCD-1
```

```
      FLAG=BLK
    1 IERR=0
      DO 3 N=1,NN
      K=0
      DO 2 I=1,NCHR
      IF(NAME(I).EQ.SAVE(I,N))K=K+1
    2 CONTINUE
      IF(K.NE.NCHR)GO TO 3
      FLAG=AST
      CALL DUPED(N,IERR)
      IF(IERR.EQ.1)GO TO 4
      GO TO 1
    3 CONTINUE
C
C     STORE THE LEFT JUSTIFIED MNEMONIC IN ARRAY SAVE
    4 DO 5 I=1,8
      SAVE(I,NRCD)=NAME(I)
    5 TEMP(I)=BLK
C
C     CENTRE THE MNEMONIC IN THE EIGHT CHARACTER FIELD
      DO 6 I=1,NCHR
      II=LEND+I
    6 TEMP(II)=NAME(I)
C
C     STORE FINAL MNEMONIC, FLAG AND ORIGINAL WORD ON TAPE 2
      WRITE (2) (TEMP(I),I=1,8),FLAG,(SAME(I),I=1,40)
      RETURN
C
      END


      SUBROUTINE DUPED(N,IERR)
C
      DIMENSION NAME(40),SAME(40),TEMP(8),SAVE(8,1000),IDIG(40),IDUM(28)
      DIMENSION NSAV(50,2),MSAV(39)
      COMMON /A/NAME,SAME,IDIG,AST,IDUM,NCHR,MCHR
      COMMON /S/SAVE,NRCD,ISAV,IAST,NS,M
      INTEGER SAME,TEMP,SAVE,AST
C
      IF(MOD(M,40).EQ.0)WRITE (3,101)
      IWDL=ISAV+IAST
      IF(IWDL.GE.40.OR.NS.GE.50)GO TO 8
      WRITE (3,102) NRCD,N
      M=M+1
      KCHR=NCHR
C
C     CHECK FOR PREVIOUS CONFLICTS AND RECORD CONFLICTING MNEMONIC NOS.
      K=1
      MSAV(1)=N
      DO 1 NN=1,NS
      IF(N.NE.NSAV(NN,1))GO TO 1
      K=K+1
      IF(K.EQ.40)GO TO 10
      MSAV(K)=NSAV(NN,2)
    1 CONTINUE
      IF(K.GE.2)WRITE (3,103) NRCD,(MSAV(KK),KK=1,K)
      NS=NS+1
      NSAV(NS,1)=N
      NSAV(NS,2)=NRCD
      IF((ISAV-K).LT.NCHR)GO TO 8
C
C     CREATE THE K-1 SHORTER MNEMONIC IF K .GT. 1
      IF(K.EQ.1)GO TO 3
      DO 2 I=1,40
      IDIG(I)=I
    2 NAME(I)=SAME(I)
      NCHR=KCHR+K-1
      MCHR=2*NCHR-2
      ICHR=ISAV
```

```
      CALL SHORT(ICHR,IAST)
C
C     CREATE A MNEMONIC K CHARACTERS LONGER THAN NCHR
    3 DO 4 I=1,8
    4 TEMP(I)=NAME(I)
      DO 5 I=1,40
      IDIG(I)=I
    5 NAME(I)=SAME(I)
      NCHR=KCHR+K
      MCHR=2*NCHR-2
      ICHR=ISAV
      CALL SHORT(ICHR,IAST)
C
C     COMPARE KM1 AND K MNEMONICS TO FIND THE LAST CHARACTER DELETED
      NCHRM1=NCHR-1
      DO 6 I=1,NCHRM1
      IF(TEMP(I).EQ.NAME(I))GO TO 6
      J=IDIG(I)
      GO TO 7
    6 CONTINUE
      J=IDIG(NCHR)
    7 CALL ASTIN(J,IWDL)
      IAST=IAST+1
C
C     RESET LENGTH OF MNEMONIC, CREATE NEW MNEMONIC, AND RETURN
      NCHR=KCHR
      MCHR=2*NCHR-2
      ICHR=ISAV
      CALL SHORT(ICHR,IAST)
      IAST=IAST-1
      WRITE (3,104)
      M=M+2
      RETURN
C
C     WRITE ERROR MESSAGES
    8 WRITE (3,105) NRCD,N,(SAME(I),I=1,40)
      M=M+2
      DO 9 I=1,NCHR
    9 NAME(I)=AST
      IERR=1
      RETURN
   10 WRITE (3,103) NRCD,N,(MSAV(KK),KK=1,K)
      M=M+1
      GO TO 8
C
  101 FORMAT (1H1,32X,26H* LIST OF ERROR MESSAGES *//)
  102 FORMAT (1H ,32X,27HCONFLICT BETWEEN MNEMONICS ,I4,4H AND,I5)
  103 FORMAT (1H ,32X,27HMULTIPLE CONFLICTS BETWEEN ,I4,4H AND,4(12I5/))
  104 FORMAT (1H ,32X,27HCONFLICT HAS BEEN RESOLVED /)
  105 FORMAT (1H ,10X,30HCONFLICT UNRESOLVABLE BETWEEN ,I4,5H AND ,I4,25
     1H PLEASE DO IT BY HAND -- ,40A1/)
C
      END


      SUBROUTINE ASTIN(J,IWDL)
C
      DIMENSION NAME(40),SAME(40),IDIG(40)
      COMMON /A/NAME,SAME,IDIG,AST
      INTEGER SAME,AST
C
C     REINTIALIZE ARRAY NAME ETC.
      DO 1 I=1,40
      IDIG(I)=I
    1 NAME(I)=SAME(I)
C
C     MOVE REQUISITE PART OF INPUT WORD ONE CHARACTER RIGHT
      I=0
      DO 2 K=J,IWDL
```

```
      KK=IWDL-I
      KKP1=KK+1
      NAME(KKP1)=NAME(KK)
    2 I=I+1
C
C     INSERT ASTERISK BEFORE CHARACTER TO BE SAVED AND RETURN
      NAME(J)=AST
      RETURN
C
      END


      SUBROUTINE PRINT(NRCD)
C
      DIMENSION MNMC(40),WORD(40),IDUM(42),CHAR(27)
      COMMON /A/MNMC,WORD,IDUM,CHAR
      INTEGER WORD,CHAR,FLAG
C
      REWIND 2
      NM=0
      NN=NRCD/2+1
      DO 3 N=1,NN
      L=N-1
      IF(MOD(L,50).EQ.0)WRITE (3,101) (CHAR(I),I=1,8),(CHAR(I),I=10,27)
      READ (2) (MNMC(I),I=1,8),FLAG,(WORD(I),I=1,40)
      IF(EOF(2))4,1
    1 NM=NM+1
      WRITE (3,102) NM,(MNMC(I),I=1,8),FLAG,(WORD(I),I=1,40)
      READ (2) (MNMC(I),I=1,8),FLAG,(WORD(I),I=1,40)
      IF(EOF(2))4,2
    2 NM=NM+1
      WRITE (3,103) NM,(MNMC(I),I=1,8),FLAG,(WORD(I),I=1,40)
    3 CONTINUE
    4 RETURN
C
  101 FORMAT (1H1,20X,95HPROGRAM TO GENERATE MNEMONICS FOR GEODAT AND OT
     1HER GEO-FILES USING THE MODIFIED FRANKLIN METHOD//10X,45HCHARACTER
     2 ELIMINATION IN THE FOLLOWING ORDER ,8A2,19HDOUBLE LETTERS AND ,18
     3A2//14X,8HMNEMONIC,7X,13HORIGINAL WORD,35X,8HMNEMONIC,7X,13HORIGIN
     4AL WORD/)
  102 FORMAT (1H ,8X,I4,1X,8A1,1X,A1,3X,40A1)
  103 FORMAT (1H+,71X,I4,1X,8A1,1X,A1,3X,40A1)
C
      END
```

APPENDIX B

STRATIGRAPHIC AGE OF SPECIMEN

(from Dawson, 1970)

01 Precambrian undivided
02 Archean (2400 m.y.)
03 Archean-Proterozoic
04 Proterozoic (600-2400 m.y.)

10 Paleozoic undivided
11 Proterozoic-Paleozoic
12 Cambrian
13 Cambrian-Ordovician
14 Ordovician
15 Ordovician-Silurian
16 Silurian
17 Silurian-Devonian
18 Devonian
19 Devonian-Mississippian
20 Carboniferous
21 Mississippian
22 Pennsylvanian
23 Pennsylvanian-Permian
24 Permian

30 Mesozoic undivided
31 Mesozoic-Paleozoic
32 Triassic
33 Triassic-Jurassic
34 Jurassic
35 Jurassic-Cretaceous
36 Cretaceous

40 Cenozoic undivided
41 Mesozoic-Cenozoic
42 Tertiary
43 Tertiary-Quaternary
44 Quaternary

50 Unknown

APPENDIX C

FREE TEXT NOTE CARD

Column	
1 - 6	NTS map-sheet part of Sample Number
7 - 12	Remainder of Sample Number
13 - 17	Text subject descriptor, a numberic code is used to identify the general subject of the text.
18 - 19	A card counter, cards are number from 01 to 99, thus allowing up to 99 cards to describe any particular feature.
20 - 79	Total of 60 columns for text or any user definable purpose.
80	9, the Master Identification Code indicating a free text card.

Note: At the Geological Survey a data base management system known as GDMS is used to handle the geochemical data. A constraint with this system is that text sections for any one text Subject Descriptor should not exceed 120 characters, i.e., 2 physical Free Text Note 80 column punch cards.