GP1/75

MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

MINERAL RESOURCES DIVISION
GEOLOGICAL SERVICES BRANCH

GEOLOGICAL PAPER 1/75

GEOLOGICAL DATA ACQUISITION STORAGE AND RETRIEVAL SYSTEMS

By
T. G. Frohlinger and W. D. McRitchie

Sept. 1975

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MINERAL RESOURCES DIVISION

GEOLOGICAL DATA ACQUISITION, STORAGE AND RETRIEVAL SYSTEMS

Introduction

In 1966 the Geological Survey Section of the Mineral Resources Division and the University of Manitoba Geology Department began work on Project Pioneer; a joint program of detailed investigations in the Rice Lake-Beresford Lake area of south-eastern Manitoba. During the planning stage of the project procedures were developed for the standardization and machine processing of the anticipated large volume of data. Prototypes of structural and petrologic field data sheets (Figures 1 and 2) were used during the 1966 field season as primary input documents. Subsequent experience has led to substantial improvements and modifications in content, format and size of the earlier data sheets. An attendant rapid increase in the size of the data file has also necessitated continuing refinements in data storage and processing techniques. The following paper outlines the evolution of the Mineral Resources Division system, describes its present components and their functions and briefly discusses intended developments.

Basic Format Requirements

Basic format requirements for data sheets were designated prior to the development of the early data sheets. It is important to note that subsequent revisions in design have not necessitated corresponding changes in the fundamental requirements for a functional design. These are:

(a) Format must be compatible with easy transfer of essential data to 80 column punch cards for retrieval and processing. (Punch cards are still used as an interim base for handling the data as they provide the capability for inexpensive card sorting functions which do not rely on access to a computer).

(b) Design should be specific yet comprehensive within the framework and aims of specific projects. (Comprehensive universal sheets, applicable to a wide variety of geological environment, are needlessly bulky and contain a large percentage of categories which remain unused during the term of individual projects).

(c) Parameters defining data characteristics should be *concise,* in that only a minimum number of terms should be coded.

(d) Coded terms should be *precise* such that all classifications and terms are defined and standardized within the project.

(e) Space should be allotted for both factual (hard-core) and interpretative (soft-core) data, each being separately and distinctly grouped.

(f) Format should allow for more than one sheet on each out-crop, but excessive duplication and repetition of reference and locational parameters from one sheet to the next should be avoided or at least minimized.

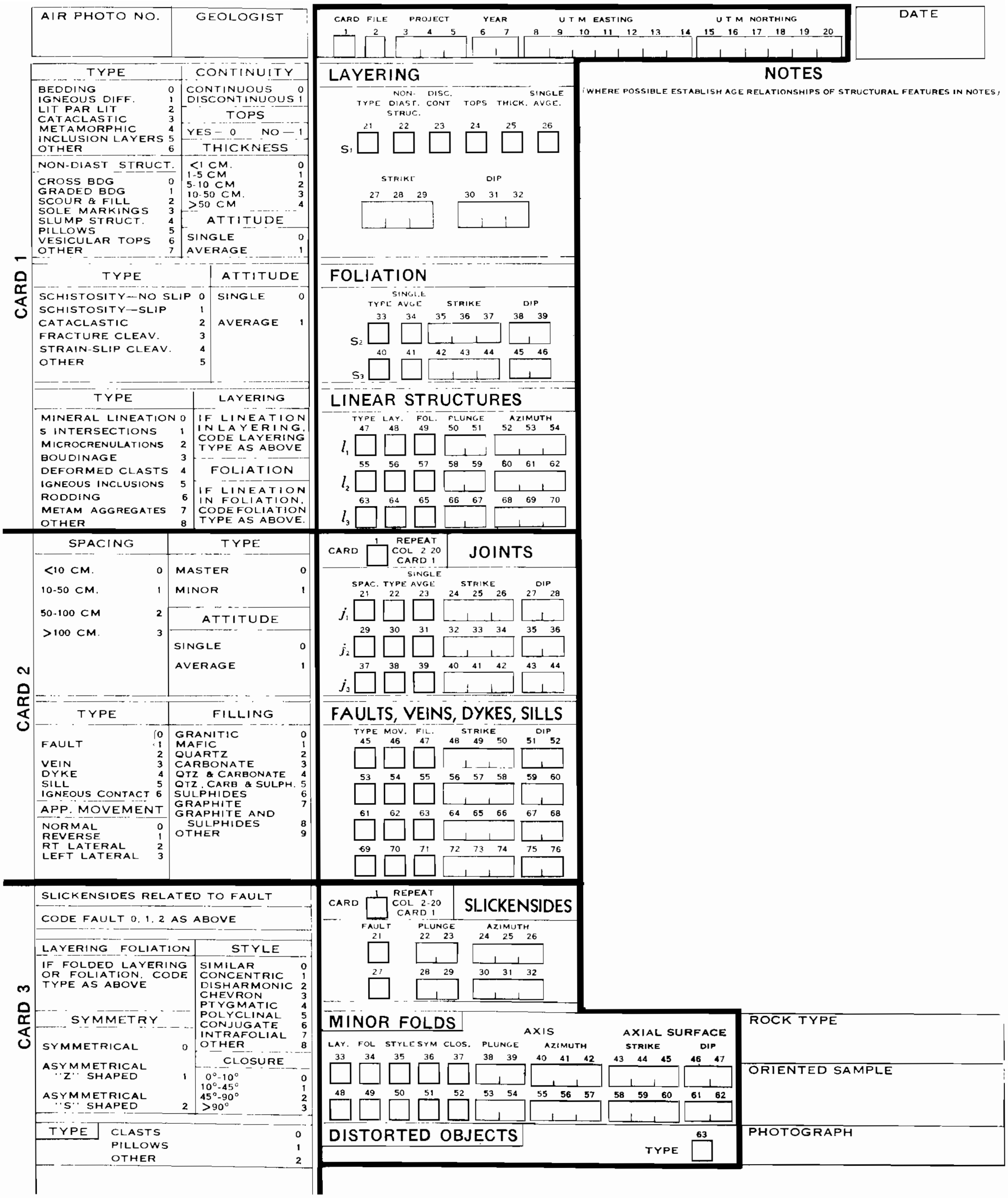
(g) Coded parameters involving quantitative "guesstimates" should be omitted. These parameters are best handled in the uncoded note sections.

Mode of Operation

The field documents are printed ahead of the field season and are used in conjunction with checklists on which the various coded data parameters are listed for reference. The current data collection procedure is based on a document (Figure 3b) in which the data items are kept separate from a flipsheet checklist (Figure 3c). The documents are available as both 5" x 7" or 8½" x 11" sheets. The smaller sheets can be accommodated in pocket size, three ring, plastic (tenite) binders. The larger sheets, which include preprinted checklists (Figure 3a) may be carried in aluminum clip boards together with aerial photographs.

Seasonal assistants are briefed in the use of the documents prior to the field season and their working efficiency is closely monitored during the early weeks of actual usage. Although rigorous definition of some terms is difficult and impractical, standardization of working criteria is essential. As field classifications evolve, periodic reviews enable project geologists to update data sheets in the field thereby maintaining compatibility of individual data files within the project.

The data sheets are also periodically verified in the field; usually at the time the station coordinates are calculated and entered. The sheets are keypunched *en masse* shortly after the



AIR PHOTO NO. | GEOLOGIST

CARD FILE PROJECT YEAR U T M EASTING U T M NORTHING
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

DATE

CARD 1

TYPE		CONTINUITY	
BEDDING	0	CONTINUOUS	0
IGNEOUS DIFF.	1	DISCONTINUOUS	1
LIT PAR LIT	2	TOPS	
CATACLASTIC	3		
METAMORPHIC	4	YES — 0 NO — 1	
INCLUSION LAYERS	5	THICKNESS	
OTHER	6		
NON-DIAST STRUCT.		<1 CM.	0
CROSS BDG	0	1-5 CM	1
GRADED BDG	1	5-10 CM	2
SCOUR & FILL	2	10-50 CM.	3
SOLE MARKINGS	3	>50 CM	4
SLUMP STRUCT.	4	ATTITUDE	
PILLOWS	5		
VESICULAR TOPS	6	SINGLE	0
OTHER	7	AVERAGE	1

LAYERING
TYPE NON-DIAST. STRUC. DISC. CONT TOPS SINGLE THICK. AVGE.
S1 21 22 23 24 25 26
STRIKE 27 28 29 DIP 30 31 32

TYPE		ATTITUDE	
SCHISTOSITY—NO SLIP	0	SINGLE	0
SCHISTOSITY—SLIP	1		
CATACLASTIC	2	AVERAGE	1
FRACTURE CLEAV.	3		
STRAIN-SLIP CLEAV.	4		
OTHER	5		

FOLIATION
TYPE SINGLE AVGE STRIKE DIP
S2 33 34 35 36 37 38 39
S3 40 41 42 43 44 45 46

TYPE		LAYERING
MINERAL LINEATION	0	IF LINEATION IN LAYERING, CODE LAYERING TYPE AS ABOVE
S INTERSECTIONS	1	
MICROCRENULATIONS	2	
BOUDINAGE	3	FOLIATION
DEFORMED CLASTS	4	
IGNEOUS INCLUSIONS	5	IF LINEATION IN FOLIATION, CODE FOLIATION TYPE AS ABOVE.
RODDING	6	
METAM AGGREGATES	7	
OTHER	8	

LINEAR STRUCTURES
TYPE LAY. FOL. PLUNGE AZIMUTH
l_1 47 48 49 50 51 52 53 54
l_2 55 56 57 58 59 60 61 62
l_3 63 64 65 66 67 68 69 70

NOTES
(WHERE POSSIBLE ESTABLISH AGE RELATIONSHIPS OF STRUCTURAL FEATURES IN NOTES)

CARD 2

SPACING		TYPE	
<10 CM.	0	MASTER	0
10-50 CM.	1	MINOR	1
50-100 CM	2	ATTITUDE	
>100 CM.	3	SINGLE	0
		AVERAGE	1

CARD 1 REPEAT COL 2 20 CARD 1
JOINTS
SPAC. TYPE SINGLE AVGE STRIKE DIP
j_1 21 22 23 24 25 26 27 28
j_2 29 30 31 32 33 34 35 36
j_3 37 38 39 40 41 42 43 44

TYPE		FILLING	
FAULT	0, 1, 2	GRANITIC	0
		MAFIC	1
		QUARTZ	2
VEIN	3	CARBONATE	3
DYKE	4	QTZ & CARBONATE	4
SILL	5	QTZ, CARB & SULPH.	5
IGNEOUS CONTACT	6	SULPHIDES	6
APP. MOVEMENT		GRAPHITE	7
NORMAL	0	GRAPHITE AND SULPHIDES	8
REVERSE	1	OTHER	9
RT LATERAL	2		
LEFT LATERAL	3		

FAULTS, VEINS, DYKES, SILLS
TYPE MOV. FIL. STRIKE DIP
45 46 47 48 49 50 51 52
53 54 55 56 57 58 59 60
61 62 63 64 65 66 67 68
69 70 71 72 73 74 75 76

CARD 3

SLICKENSIDES RELATED TO FAULT
CODE FAULT 0, 1, 2 AS ABOVE

CARD 1 REPEAT COL 2-20 CARD 1
SLICKENSIDES
FAULT PLUNGE AZIMUTH
21 22 23 24 25 26
27 28 29 30 31 32

LAYERING FOLIATION		STYLE	
IF FOLDED LAYERING OR FOLIATION, CODE TYPE AS ABOVE		SIMILAR	0
		CONCENTRIC	1
		DISHARMONIC	2
		CHEVRON	3
SYMMETRY		PTYGMATIC	4
		POLYCLINAL	5
		CONJUGATE	6
		INTRAFOLIAL	7
SYMMETRICAL	0	OTHER	8
ASYMMETRICAL "Z" SHAPED	1	CLOSURE	
		0°-10°	0
		10°-45°	1
ASYMMETRICAL "S" SHAPED	2	45°-90°	2
		>90°	3

TYPE		
	CLASTS	0
	PILLOWS	1
	OTHER	2

MINOR FOLDS
LAY. FOL STYLE SYM CLOS. PLUNGE AXIS AZIMUTH AXIAL SURFACE STRIKE DIP
33 34 35 36 37 38 39 40 41 42 43 44 45 46 47
48 49 50 51 52 53 54 55 56 57 58 59 60 61 62

DISTORTED OBJECTS
TYPE 63

ROCK TYPE
ORIENTED SAMPLE
PHOTOGRAPH

Figure 1: Structural data field sheet, 1966.

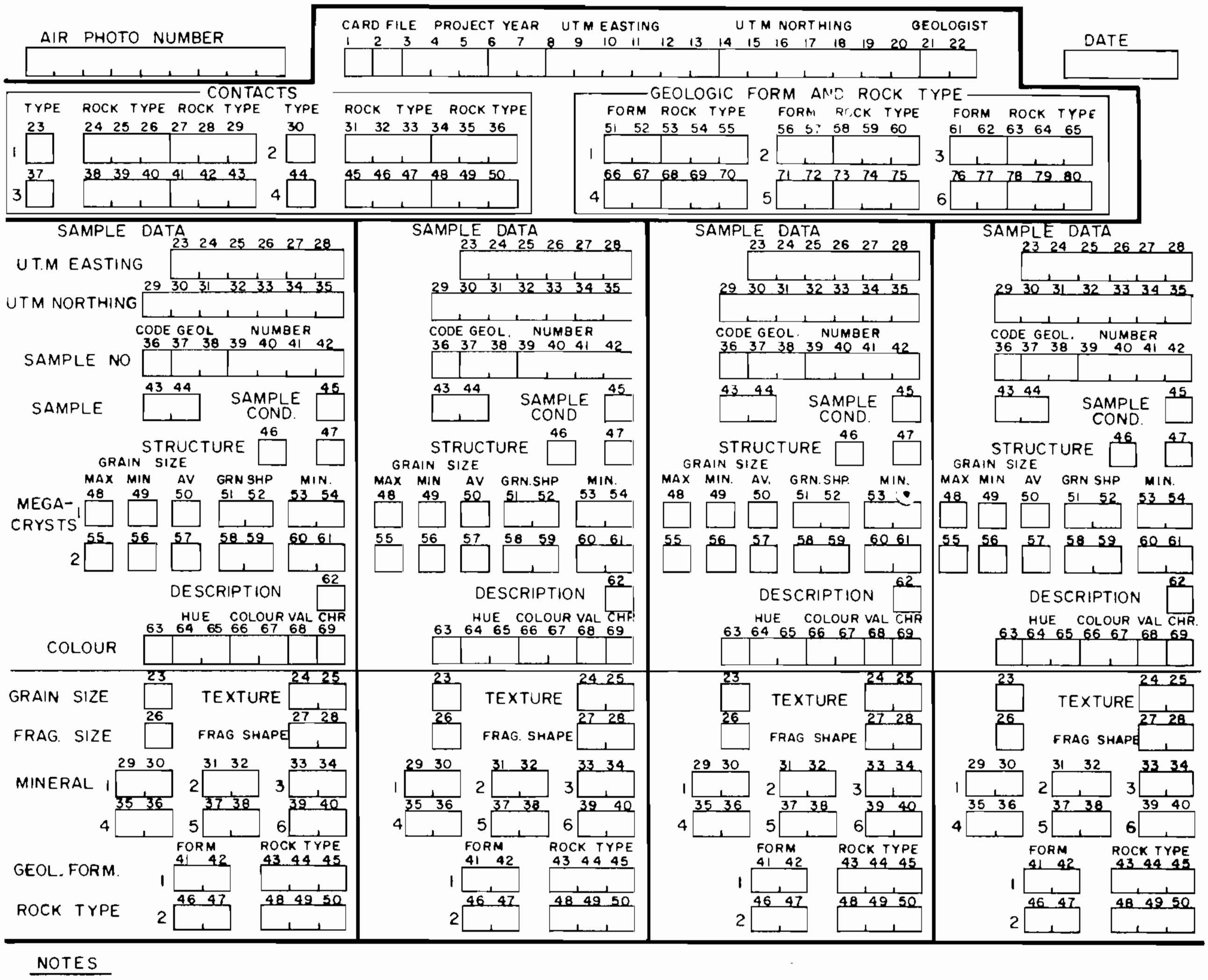
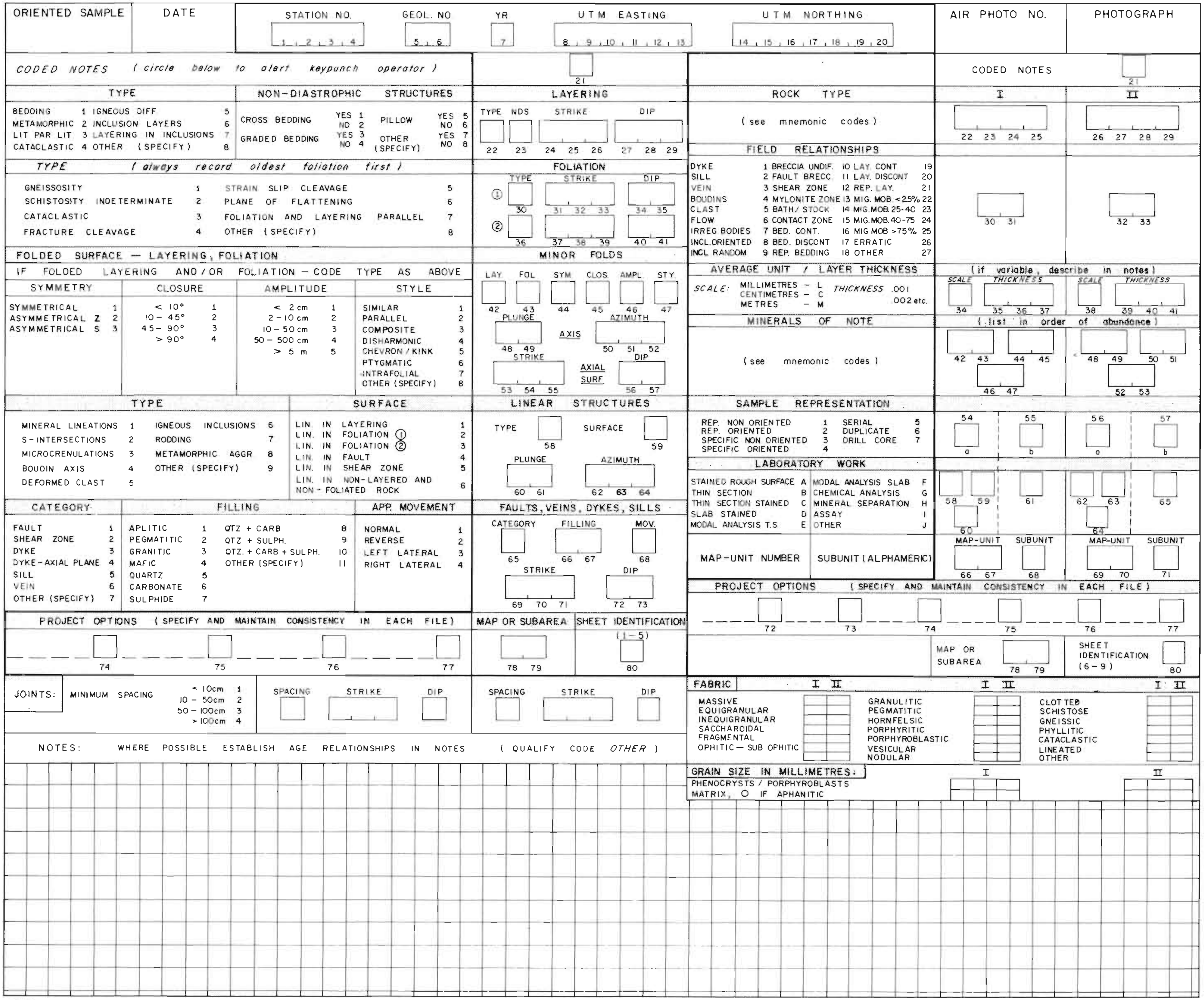

AIR PHOTO NUMBER
CARD FILE PROJECT YEAR UTM EASTING UTM NORTHING GEOLOGIST
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
DATE
CONTACTS
TYPE ROCK TYPE ROCK TYPE TYPE ROCK TYPE ROCK TYPE
23 24 25 26 27 28 29 30 31 32 33 34 35 36
37 38 39 40 41 42 43 44 45 46 47 48 49 50
GEOLOGIC FORM AND ROCK TYPE
FORM ROCK TYPE FORM ROCK TYPE FORM ROCK TYPE
51 52 53 54 55 56 57 58 59 60 61 62 63 64 65
66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
SAMPLE DATA
UTM EASTING 23 24 25 26 27 28
UTM NORTHING 29 30 31 32 33 34 35
SAMPLE NO CODE GEOL NUMBER 36 37 38 39 40 41 42
SAMPLE 43 44 SAMPLE COND. 45
STRUCTURE 46 47
MEGA-CRYSTS GRAIN SIZE MAX MIN AV GRN SHP MIN.
1 48 49 50 51 52 53 54
2 55 56 57 58 59 60 61
DESCRIPTION 62
COLOUR HUE COLOUR VAL CHR 63 64 65 66 67 68 69
GRAIN SIZE 23 TEXTURE 24 25
FRAG. SIZE 26 FRAG SHAPE 27 28
MINERAL 1 29 30 2 31 32 3 33 34
4 35 36 5 37 38 6 39 40
GEOL. FORM. ROCK TYPE FORM ROCK TYPE
1 41 42 43 44 45
2 46 47 48 49 50
NOTES

Figure 2: Petrological data field sheet, 1966.



ORIENTED SAMPLE | DATE | STATION NO. 1 2 3 4 | GEOL. NO 5 6 | YR 7 | UTM EASTING 8 9 10 11 12 13 | UTM NORTHING 14 15 16 17 18 19 20 | AIR PHOTO NO. | PHOTOGRAPH

CODED NOTES (circle below to alert keypunch operator) 21

TYPE
BEDDING 1 IGNEOUS DIFF 5
METAMORPHIC 2 INCLUSION LAYERS 6
LIT PAR LIT 3 LAYERING IN INCLUSIONS 7
CATACLASTIC 4 OTHER (SPECIFY) 8

NON-DIASTROPHIC STRUCTURES
CROSS BEDDING YES 1 NO 2 PILLOW YES 5 NO 6
GRADED BEDDING YES 3 NO 4 OTHER (SPECIFY) YES 7 NO 8

LAYERING
TYPE 22 NDS 23 STRIKE 24 25 26 DIP 27 28 29

TYPE (always record oldest foliation first)
GNEISSOSITY 1 STRAIN SLIP CLEAVAGE 5
SCHISTOSITY INDETERMINATE 2 PLANE OF FLATTENING 6
CATACLASTIC 3 FOLIATION AND LAYERING PARALLEL 7
FRACTURE CLEAVAGE 4 OTHER (SPECIFY) 8

FOLIATION
① TYPE 30 STRIKE 31 32 33 DIP 34 35
② 36 37 38 39 40 41

FOLDED SURFACE — LAYERING, FOLIATION
IF FOLDED LAYERING AND / OR FOLIATION — CODE TYPE AS ABOVE

SYMMETRY		CLOSURE		AMPLITUDE		STYLE	
SYMMETRICAL	1	< 10°	1	< 2 cm	1	SIMILAR	1
ASYMMETRICAL Z	2	10 – 45°	2	2 – 10 cm	2	PARALLEL	2
ASYMMETRICAL S	3	45 – 90°	3	10 – 50 cm	3	COMPOSITE	3
		> 90°	4	50 – 500 cm	4	DISHARMONIC	4
				> 5 m	5	CHEVRON / KINK	5
						PTYGMATIC	6
						INTRAFOLIAL	7
						OTHER (SPECIFY)	8

MINOR FOLDS
LAY 42 FOL 43 SYM 44 CLOS 45 AMPL 46 STY 47
AXIS: PLUNGE 48 49 AZIMUTH 50 51 52
AXIAL SURF: STRIKE 53 54 55 DIP 56 57

TYPE
MINERAL LINEATIONS 1 IGNEOUS INCLUSIONS 6
S-INTERSECTIONS 2 RODDING 7
MICROCRENULATIONS 3 METAMORPHIC AGGR 8
BOUDIN AXIS 4 OTHER (SPECIFY) 9
DEFORMED CLAST 5

SURFACE
LIN. IN LAYERING 1
LIN. IN FOLIATION ① 2
LIN. IN FOLIATION ② 3
LIN. IN FAULT 4
LIN. IN SHEAR ZONE 5
LIN. IN NON-LAYERED AND NON-FOLIATED ROCK 6

LINEAR STRUCTURES
TYPE 58 SURFACE 59
PLUNGE 60 61 AZIMUTH 62 63 64

CATEGORY
FAULT 1
SHEAR ZONE 2
DYKE 3
DYKE-AXIAL PLANE 4
SILL 5
VEIN 6
OTHER (SPECIFY) 7

FILLING
APLITIC 1 QTZ + CARB 8
PEGMATITIC 2 QTZ + SULPH. 9
GRANITIC 3 QTZ. + CARB + SULPH. 10
MAFIC 4 OTHER (SPECIFY) 11
QUARTZ 5
CARBONATE 6
SULPHIDE 7

APP. MOVEMENT
NORMAL 1
REVERSE 2
LEFT LATERAL 3
RIGHT LATERAL 4

FAULTS, VEINS, DYKES, SILLS
CATEGORY 65 FILLING 66 67 MOV. 68
STRIKE 69 70 71 DIP 72 73

PROJECT OPTIONS (SPECIFY AND MAINTAIN CONSISTENCY IN EACH FILE) 74 75 76 77
MAP OR SUBAREA 78 79
SHEET IDENTIFICATION (1 – 5) 80

JOINTS: MINIMUM SPACING < 10cm 1, 10 – 50cm 2, 50 – 100cm 3, > 100cm 4
SPACING STRIKE DIP | SPACING STRIKE DIP

NOTES: WHERE POSSIBLE ESTABLISH AGE RELATIONSHIPS IN NOTES (QUALIFY CODE OTHER)

ROCK TYPE
(see mnemonic codes)
CODED NOTES 21
I 22 23 24 25 | II 26 27 28 29

FIELD RELATIONSHIPS
DYKE 1 BRECCIA UNDIF. 10 LAY. CONT 19
SILL 2 FAULT BRECC. 11 LAY. DISCONT 20
VEIN 3 SHEAR ZONE 12 REP. LAY. 21
BOUDINS 4 MYLONITE ZONE 13 MIG. MOB <25% 22
CLAST 5 BATH / STOCK 14 MIG. MOB 25-40 23
FLOW 6 CONTACT ZONE 15 MIG. MOB 40-75 24
IRREG BODIES 7 BED. CONT. 16 MIG MOB >75% 25
INCL. ORIENTED 8 BED. DISCONT 17 ERRATIC 26
INCL RANDOM 9 REP. BEDDING 18 OTHER 27
30 31 | 32 33

AVERAGE UNIT / LAYER THICKNESS
SCALE: MILLIMETRES – L, CENTIMETRES – C, METRES – M; THICKNESS .001, .002 etc.
(if variable, describe in notes)
SCALE 34 THICKNESS 35 36 37 | SCALE 38 THICKNESS 39 40 41

MINERALS OF NOTE
(see mnemonic codes)
(list in order of abundance)
42 43 44 45 46 47 | 48 49 50 51 52 53

SAMPLE REPRESENTATION
REP. NON ORIENTED 1 SERIAL 5
REP. ORIENTED 2 DUPLICATE 6
SPECIFIC NON ORIENTED 3 DRILL CORE 7
SPECIFIC ORIENTED 4
54 a 55 b | 56 a 57 b

LABORATORY WORK
STAINED ROUGH SURFACE A MODAL ANALYSIS SLAB F
THIN SECTION B CHEMICAL ANALYSIS G
THIN SECTION STAINED C MINERAL SEPARATION H
SLAB STAINED D ASSAY I
MODAL ANALYSIS T.S E OTHER J
58 59 60 61 | 62 63 64 65

MAP-UNIT NUMBER | SUBUNIT (ALPHAMERIC)
MAP-UNIT 66 67 SUBUNIT 68 | MAP-UNIT 69 70 SUBUNIT 71

PROJECT OPTIONS (SPECIFY AND MAINTAIN CONSISTENCY IN EACH FILE) 72 73 74 75 76 77
MAP OR SUBAREA 78 79
SHEET IDENTIFICATION (6 – 9) 80

FABRIC I II
MASSIVE, EQUIGRANULAR, INEQUIGRANULAR, SACCHAROIDAL, FRAGMENTAL, OPHITIC — SUB OPHITIC
GRANULITIC, PEGMATITIC, HORNFELSIC, PORPHYRITIC, PORPHYROBLASTIC, VESICULAR, NODULAR
CLOTTED, SCHISTOSE, GNEISSIC, PHYLLITIC, CATACLASTIC, LINEATED, OTHER

GRAIN SIZE IN MILLIMETRES: I II
PHENOCRYSTS / PORPHYROBLASTS
MATRIX, O IF APHANITIC

9 4-74-10M
MNR-m-38

Figure 3a: Combined structural and petrological field data sheet, 1974. 8½" x 11".

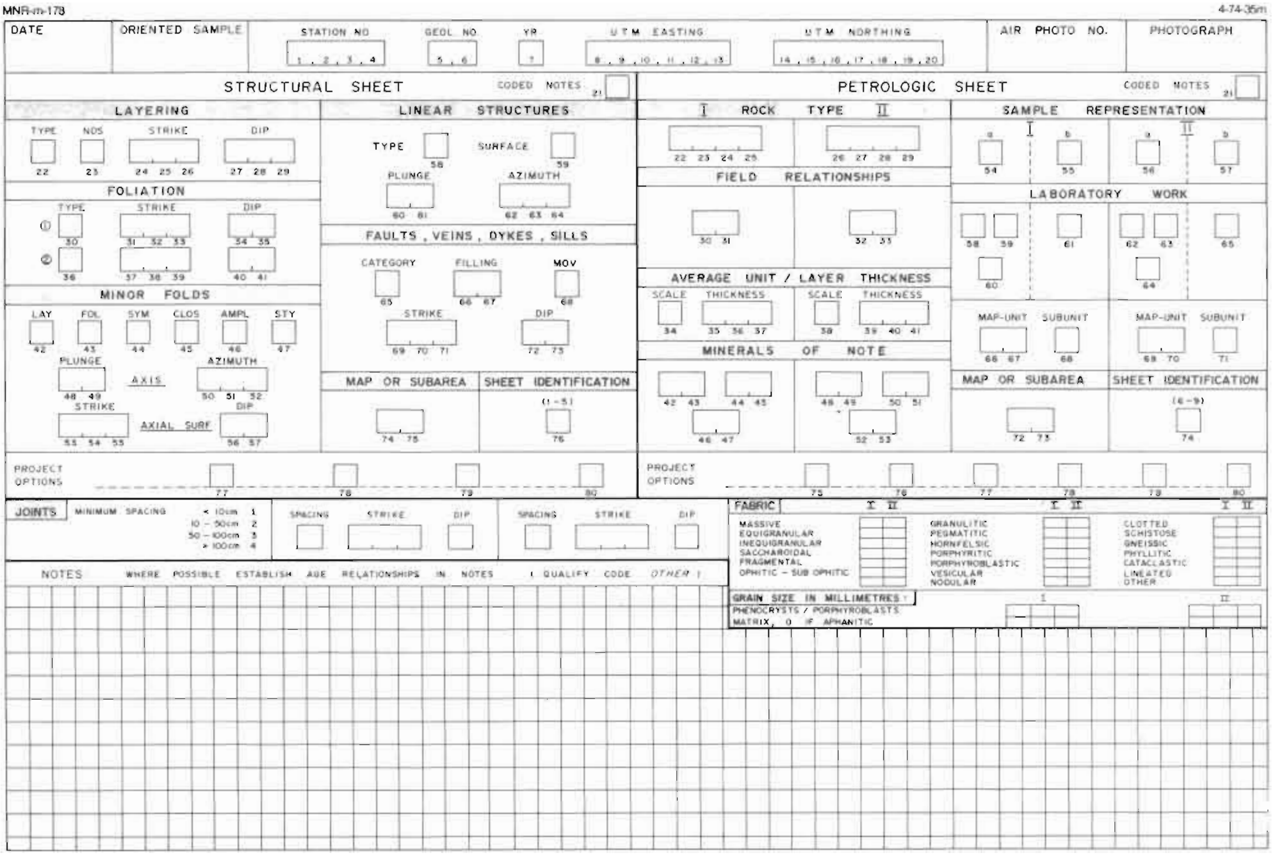


Figure 3b: Combined structural and petrological field data sheet, 1974. 5" x 7".

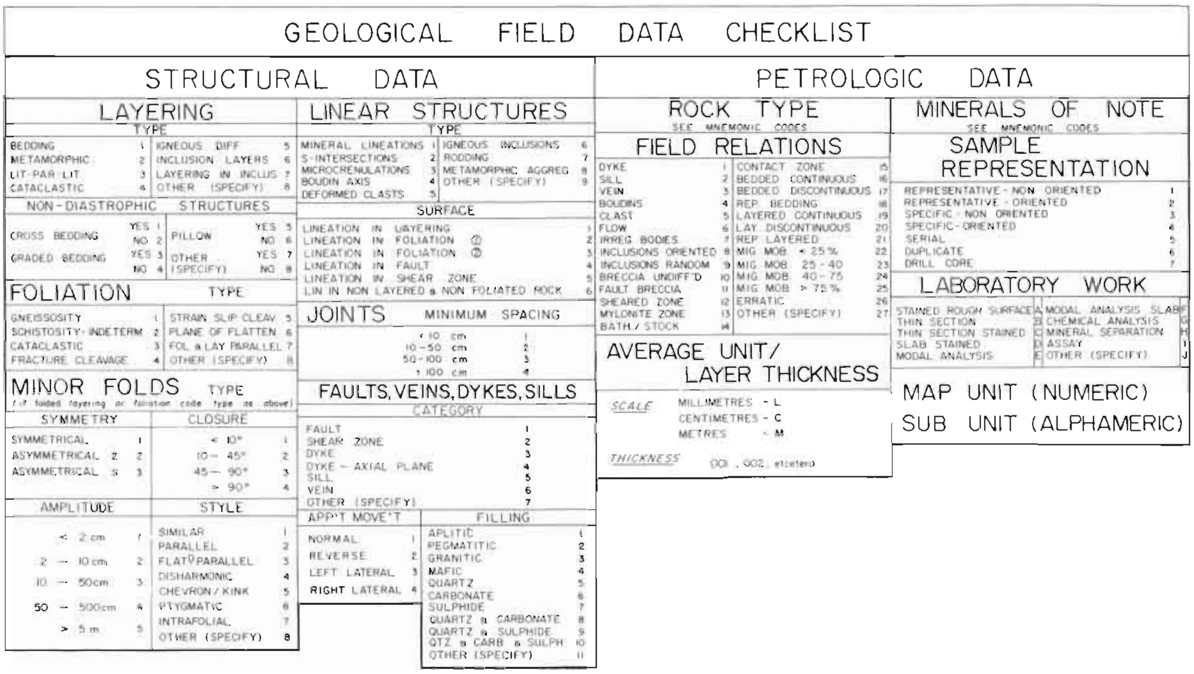


Figure 3c: Checklist for 1974 combined structural and petrological field and data sheet.

conclusion of the field programme. After keypunching and file updating the data sheets are bound into permanent note books containing between 200 and 250 documents. These books are used extensively thereafter by the project geologists and are stored in the archives at the conclusion of each project. A schematic flow sheet of the Mineral Resources Division system is presented in Figure 4.

Description of Data Sheets

Field Sheets

A) Structural Data

A prototype structural field data sheet (Figure 1) was used with considerable success throughout the 1966 field season. It was revised and modified in 1967 (Haugh et al, 1967). In 1970 the earlier structural format was revised in conjunction with the development of an independent petrologic data sheet (Figure 5). The section dealing with sample data was eliminated and a sheet identification capability was added. Further revisions in 1971 included allowance for additional joint readings and a change to the 5" x 7" sheet size (Figure 6a). This design proved functional and was used until 1973. The current (1974) structural field data sheet introduces several minor changes including:

(a) expansion of foliation categories to allow up to two readings per station;

(b) removal of joints and fabric to coded not keypunched section.

A full description is given in Appendix 1. The sheet is nearly universal in that it can be adapted with only minor modifications to studies of other Precambrian areas. In addition to its machine processibility, the data sheet by virtue of its design provides a checklist and a means of recording structural field data in an orderly and systematic manner. This in itself offers substantial advantages as a tool in geological mapping.

B) Petrologic Data

The prototype of a petrological data sheet (Figure 2) was also used in 1966. It was found at that time that the two sheets were awkward to handle and involved unnecessary duplication in recording of file headings, locations and other reference parameters. The design of this field sheet violated several aspects of the basic format requirements in that:

(a) numerous categories involved "guesstimates" which were later accurately determined in the laboratory;

(b) several parameters were not comprehensively defined under the coding groups provided.

During the 1967 revision of procedures (Haugh et al, 1967) the petrologic data sheet was eliminated as a separate entity, and the structural and petrologic sheets were combined. The resulting data sheet in practice was found to be petrologically weak as rigid formatting inhibited the variety and range of rock type that could be recorded. The problem was partially overcome by extensive use of box 21 which allowed coding of free format notes. It was this weakness of the combined field sheets that prompted the re-introduction of a separate petrological data sheet in 1970. The two sheets were combined to fit an 8½" x 11" horizontal format (Figure 5) for ease of handling.

The format and to a lesser extent the content of both data sheets were again revised in 1971. A 5" x 7" vertical format was designed with the structural sheet on the front, and a petrologic sheet on the back side of each page (Figures 6a and 6b). Separate sheets headed by only station identification parameters were used for sketches. The petrologic sheet was revised by adding and redefining many of the parameters. Provision was also made for coding both major and minor rock fabric elements.

However, the 1971 format was not favoured by the geologists because of the double sided nature of the document and the necessity of using a second, separate sheet for sketches. It was felt by all users that a single, one sided sheet was the more expedient format. To comply with these restrictions all codes were removed from the input document (Figure 7a) and were transferred to a separate checklist (Figure 7b). The resulting saving of space allowed the combination of the structural and petrologic data sheets into the 5" x 7" document format. The basic design of the document proved most successful and was used until 1973 after which several minor changes in content were made. The current (1974) document is described fully in Appendix 1.

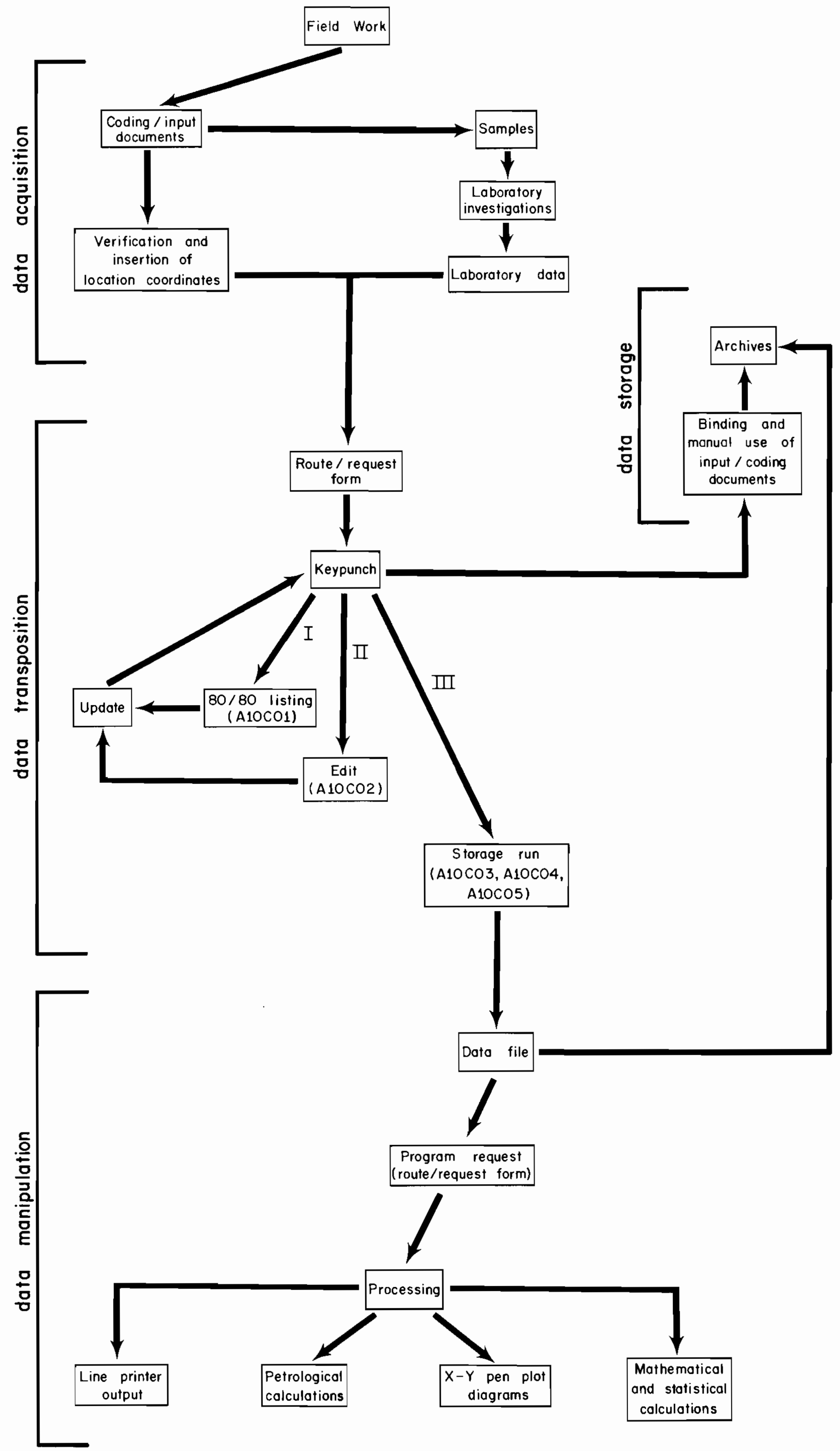


Figure 4: Schematic flow sheet of the Mineral Resources Division system.

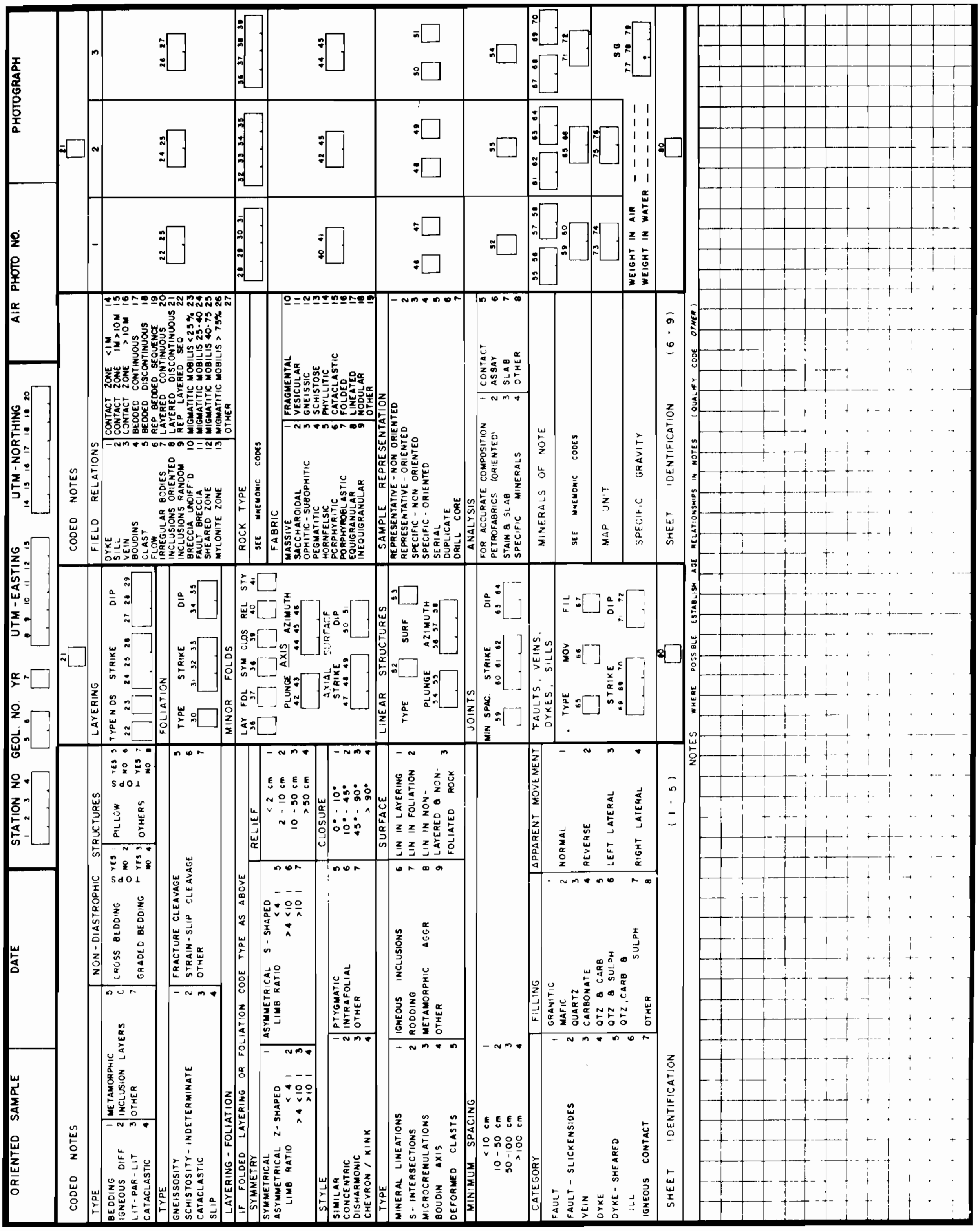


Figure 5: Combined structural and petrological field data sheet, 1970.

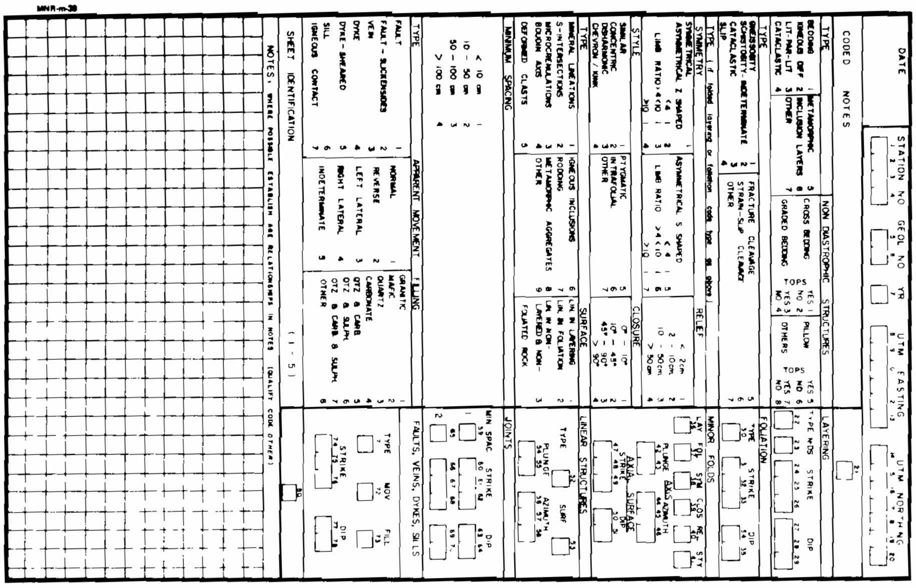


Figure 6a: Structural field data sheet, 1971.

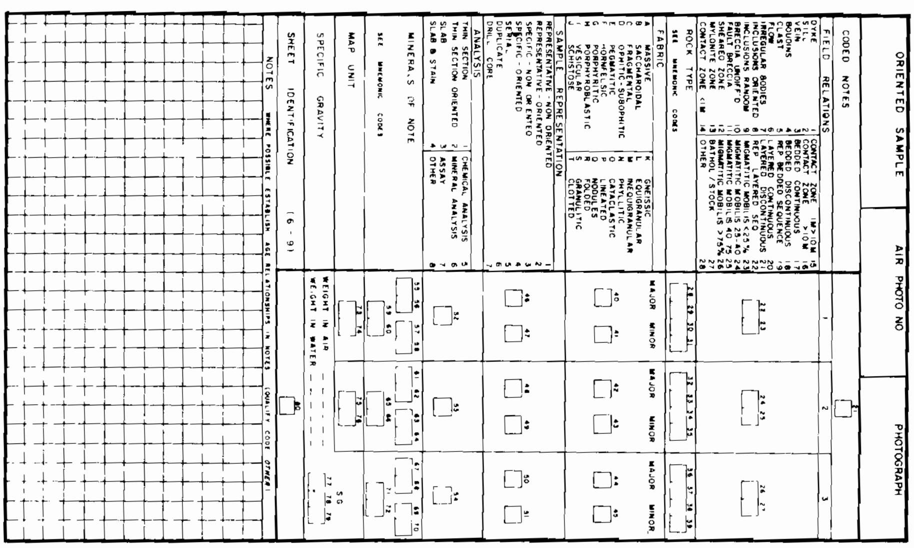


Figure 6b: Petrological field data sheet, 1971.

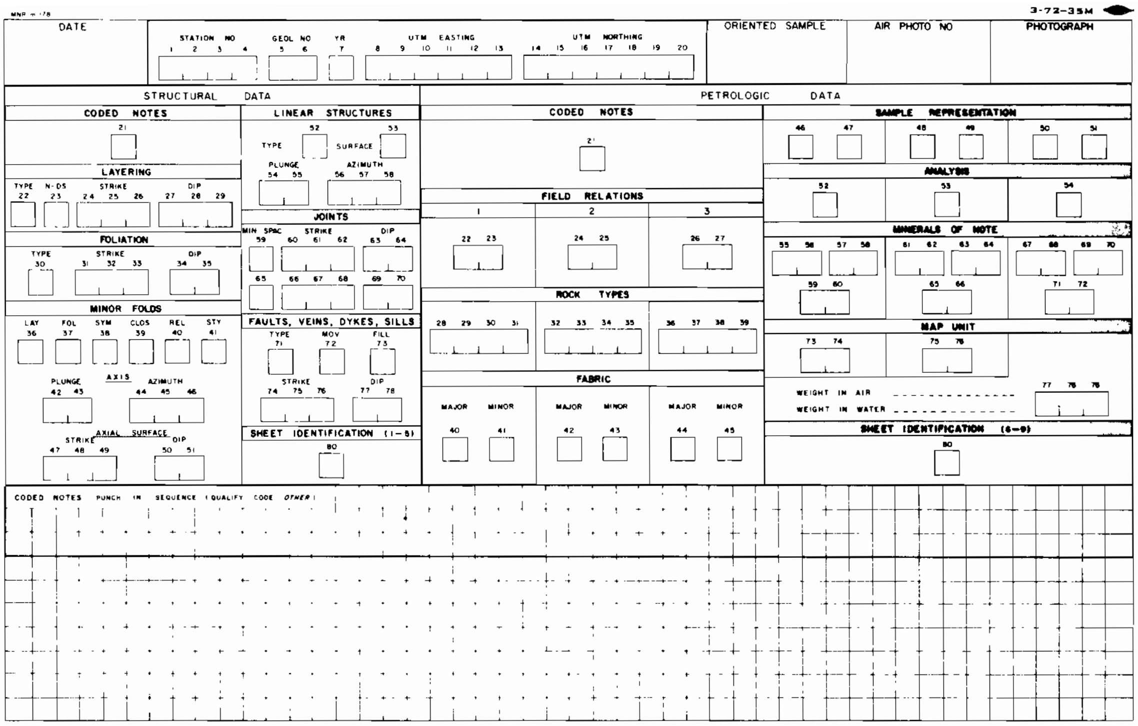
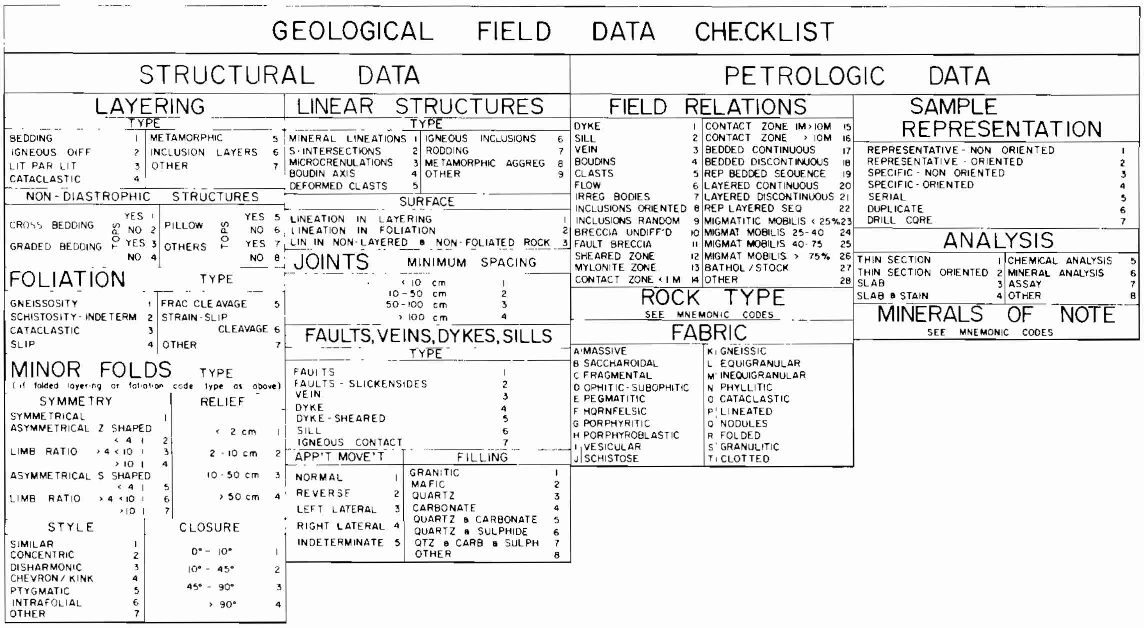


Figure 7a: Combined structural and petrological field data sheet, 1973. 5" x 7".



GEOLOGICAL FIELD DATA CHECKLIST

STRUCTURAL DATA

LAYERING — TYPE
BEDDING 1
IGNEOUS DIFF 2
LIT PAR LIT 3
CATACLASTIC 4
METAMORPHIC 5
INCLUSION LAYERS 6
OTHER 7

NON-DIASTROPHIC STRUCTURES
CROSS BEDDING — TOPS YES 1, NO 2
GRADED BEDDING — TOPS YES 3, NO 4
PILLOW — TOPS YES 5, NO 6
OTHERS — TOPS YES 7, NO 8

FOLIATION — TYPE
GNEISSOSITY 1
SCHISTOSITY-INDETERM 2
CATACLASTIC 3
SLIP 4
FRAC CLEAVAGE 5
STRAIN-SLIP CLEAVAGE 6
OTHER 7

MINOR FOLDS — TYPE (if folded layering or foliation code type as above)
SYMMETRY
SYMMETRICAL 1
ASYMMETRICAL Z SHAPED — LIMB RATIO < 4 2, > 4 < 10 3, > 10 4
ASYMMETRICAL S SHAPED — LIMB RATIO < 4 5, > 4 < 10 6, > 10 7
RELIEF
< 2 cm 1
2 - 10 cm 2
10 - 50 cm 3
> 50 cm 4
STYLE
SIMILAR 1
CONCENTRIC 2
DISHARMONIC 3
CHEVRON / KINK 4
PTYGMATIC 5
INTRAFOLIAL 6
OTHER 7
CLOSURE
0° - 10° 1
10° - 45° 2
45° - 90° 3
> 90° 4

LINEAR STRUCTURES — TYPE
MINERAL LINEATIONS 1
S-INTERSECTIONS 2
MICROCRENULATIONS 3
BOUDIN AXIS 4
DEFORMED CLASTS 5
IGNEOUS INCLUSIONS 6
RODDING 7
METAMORPHIC AGGREG 8
OTHER 9
SURFACE
LINEATION IN LAYERING 1
LINEATION IN FOLIATION 2
LIN IN NON-LAYERED & NON-FOLIATED ROCK 3

JOINTS — MINIMUM SPACING
< 10 cm 1
10 - 50 cm 2
50 - 100 cm 3
> 100 cm 4

FAULTS, VEINS, DYKES, SILLS — TYPE
FAULTS 1
FAULTS - SLICKENSIDES 2
VEIN 3
DYKE 4
DYKE - SHEARED 5
SILL 6
IGNEOUS CONTACT 7
APP'T MOVE'T
NORMAL 1
REVERSE 2
LEFT LATERAL 3
RIGHT LATERAL 4
INDETERMINATE 5
FILLING
GRANITIC 1
MAFIC 2
QUARTZ 3
CARBONATE 4
QUARTZ & CARBONATE 5
QUARTZ & SULPHIDE 6
QTZ & CARB & SULPH 7
OTHER 8

PETROLOGIC DATA

FIELD RELATIONS
DYKE 1
SILL 2
VEIN 3
BOUDINS 4
CLASTS 5
FLOW 6
IRREG BODIES 7
INCLUSIONS ORIENTED 8
INCLUSIONS RANDOM 9
BRECCIA UNDIFF'D 10
FAULT BRECCIA 11
SHEARED ZONE 12
MYLONITE ZONE 13
CONTACT ZONE < 1 M 14
CONTACT ZONE 1M > 10M 15
CONTACT ZONE > 10M 16
BEDDED CONTINUOUS 17
BEDDED DISCONTINUOUS 18
REP BEDDED SEQUENCE 19
LAYERED CONTINUOUS 20
LAYERED DISCONTINUOUS 21
REP LAYERED SEQ 22
MIGMATITIC MOBILIS < 25% 23
MIGMAT MOBILIS 25-40 24
MIGMAT MOBILIS 40-75 25
MIGMAT MOBILIS > 75% 26
BATHOL / STOCK 27
OTHER 28

ROCK TYPE — SEE MNEMONIC CODES

FABRIC
A MASSIVE
B SACCHAROIDAL
C FRAGMENTAL
D OPHITIC-SUBOPHITIC
E PEGMATITIC
F HORNFELSIC
G PORPHYRITIC
H PORPHYROBLASTIC
I VESICULAR
J SCHISTOSE
K GNEISSIC
L EQUIGRANULAR
M INEQUIGRANULAR
N PHYLLITIC
O CATACLASTIC
P LINEATED
Q NODULES
R FOLDED
S GRANULITIC
T CLOTTED

SAMPLE REPRESENTATION
REPRESENTATIVE - NON ORIENTED 1
REPRESENTATIVE - ORIENTED 2
SPECIFIC - NON ORIENTED 3
SPECIFIC - ORIENTED 4
SERIAL 5
DUPLICATE 6
DRILL CORE 7

ANALYSIS
THIN SECTION 1
THIN SECTION ORIENTED 2
SLAB 3
SLAB & STAIN 4
CHEMICAL ANALYSIS 5
MINERAL ANALYSIS 6
ASSAY 7
OTHER 8

MINERALS OF NOTE — SEE MNEMONIC CODES

Figure 7b: Checklist for 1973 combined structural and petrological field data sheet.

C) Geochemical Data

The prototype geochemical data sheet (Figures 8a and 8b) was used successfully in geochemical sampling programs conducted during the 1972 and 1973 field seasons. The concept is an extension of that used for geological data acquisition. In preparing the data sheet the following criteria were taken into consideration in addition to those dictated by the Basic Format Requirements:

(a) all pertinent geochemical observations must be reduced to numerical form for uniform presentation, objectivity and ease of comparison;

(b) provision should be made for additional descriptive notes and sketches;

(c) the data sheet should be universal in so far as field data on all geochemical sample media likely to be encountered in the program must be accommodated by the 80-column format.

A detailed description of the geochemical data sheet is presented in Appendix II.

Laboratory Sheets

A) Petographic Data

The large numbers of samples collected during individual projects require an efficient data handling system designed for laboratory use. A petrographic data sheet was designed (McRitchie, 1969) with the aim of providing a convenient and comprehensive format for recording hand-specimen and petrographic descriptions in a form that readily lent itself to computer-oriented data conversion, storage, retrieval and processing techniques.

In operation, the input document is used in conjunction with a checklist on which descriptive parameters have been coded into a processable form. Full details on the petrographic laboratory data sheet are available in McRitchie (1969).

Miscellaneous Sheets

In addition to the above sheets a number of data sheets have been designed to aid in systematic recording and manipulation of quantitative laboratory data. As these sheets require no other input than the recording of the data on an 80-column coding document, they are merely listed for the record. Descriptions and illustrations of these documents are given in Ambach, 1972.

(1) Specific Gravity

(2) Geochemical Laboratory Data Sheet I.

(3) Geochemical Laboratory Data Sheet II.

(4) Line Printer Ternary Data Sheet.

(5) Chemical Analysis Laboratory Sheet.

(6) X-Y Variation Data Sheet.

(7) Bar Plot Data Sheet.

(8) Korzhinskii Plot Data Sheet.

(9) Pen Plotter Ternary Data Sheet.

(10) Pen Plotter Least-Squares Data Sheet.

Data Decoding

At the present time some 45 computer programs are available through the Mineral Resources Division for the manipulation of data files based on the previously described data sheets. A description of program characteristics is available (Ambach, 1972), and Tables 1-6 are presented only as brief summary of these programs.

The smooth flow of large volumes of data is ensured by the route/request form (Figure 9) which each geologist completes prior to submission of data for processing. Even with relatively low priority, this document makes possible turn-around time of less than three days. Mnemonic codes are used to identify individual minerals and rock types in the input, for the petrologic data decode programs (Table 2) and the petrographic laboratory sheet. The "Franklin Method" has been

DATE	STATION NO. 1 2 3 4	GEOL. NO. 5 6	YR. 7	U.T.M. EASTING 8 9 10 11 12 13	U.T.M. NORTHING 14 15 16 17 18 19 20	AIR PHOTO NO.	PHOTOGRAPH

SAMPLE DATA						COLLECTION SITE DATA		
SAMPLE MEDIA	GLACIAL DRIFT - SOIL - SEDIMENT				NATURAL WATER	VEGETATION	RELIEF	DRAINAGE
	TEXTURE OR TYPE		COLOUR		TURBIDITY / COLOUR	DOMINANT COVER	GROUND-BANK SLOPE	
21	22	23	24	25	26 / 27	28	29	30
GLACIAL TYPE	WATER TYPE	SOIL HORIZON			VEGETATION: TYPE / ORGAN	WATER CHANNEL OR BASIN: FLOW RATE / DEPTH	WIDTH-AREA / POSITION	MINERALIZATION
31	32	33	34		35 / 36 37	38 / 39	40 / 41	42
GLACIAL DRIFT-SOIL-SEDIMENT DEPTH		ROCK TYPES: BEDROCK			FRAGMENTS	MINERALS OF NOTE	FIELD TESTS: WATER TEMP. / pH	OTHER
43 44 45 m.	46 47 48 m	49 50 51 52	53 54 55 56		57 58 59 60	61 62 63 64	65 66 / 67 68 °C	69 70 71
CODED NOTES (1-9)	NO. OF SAMPLES (1-9)	MISCELLANEOUS				GLACIAL STRIAE AZIMUTH	SHEET IDENTIFICATION (1-9)	
72	73	74				75 76 77	80	

NOTES (QUALIFY CODE OTHER)

Figure 8a: Geochemical data sheet, 1973.

GEOCHEMICAL FIELD DATA CHECKLIST

SAMPLE DATA

SAMPLE MEDIA		GLACIAL DRIFT - SOIL - SEDIMENT: TEXTURE OR TYPE		COLOUR		NATURAL WATER: TURBIDITY	
GLACIAL DRIFT	1	GRAVEL FRAGMENTS	1	BLACK	1	CLEAR TO HEAVILY TURBID (1-9)	
SOIL	2	COARSE SAND	2	BLUISH - BLACK	2	**COLOUR**	
STREAM SEDIMENT	3	FINE SAND	3	DARK GREY	3	COLOURLESS TO HIGHLY COLOURED (1-9)	
LAKE SEDIMENT	4	SILT	4	LIGHT GREY	4		
NATURAL WATER	5	CLAY	5	DARK BROWN	5		
PRECIPITATE	6	VARVED	6	LIGHT BROWN	6		
VEGETATION	7	ORGANIC	7	GREYISH - BROWN	7		
BEDROCK	8			BUFF	8		
OTHER	9			OTHER	9		

GLACIAL TYPE		WATER TYPE		SOIL HORIZON		VEGETATION: TYPE	
TILL	1	SWAMP	1	Ao - ORGANIC LITTER	1	SPRUCE	1
MORAINE	2	SEEPAGE	2	A1 - HUMUS - DARK	2	POPLAR	2
KAME	3	SPRING	3	A2 - LEACHED - LIGHT	3	BIRCH	3
ESKER	4	STREAM	4	B - ENRICHED - DARK	4	ALDER	4
OUTWASH SED.	5	RIVER	5	C - UNDIFFERENTIATED PARENT MATERIAL	5	OTHER	5
LAKE SEDIMENT	6	POND	6			**ORGAN**	
DRUMLIN	7	LAKE	7			LEAF - NEEDLE	1
ERRATIC BOULDER	8	DRILLHOLE	8			TWIG	2
OTHER	9	OTHER	9			BARK	3

COLLECTION SITE DATA

VEGETATION: DOMINANT COVER		RELIEF: GROUND-BANK-SLOPE		DRAINAGE	
EVERGREEN	1	< 5°	1	WATERLOGGED	1
BROADLEAF	2	5° - 15°	2	POOR	2
MIXED (1+2)	3	15° - 30°	3	MODERATE	3
MUSKEG	4	30° - 45°	4	GOOD	4
ABSENT	5	> 45°	5		

WATER CHANNEL OR BASIN: FLOW RATE		WIDTH - AREA		MINERALIZATION	
STILL	1	< 1 m or sq km	1	MASSIVE SULPHIDE	1
SLOW	2	1-2 m or sq km	2	DISSEMINATED SULPHIDE	2
MODERATE	3	2-3 m or sq km	3	VEIN SULPHIDE / PRECIOUS METAL	3
RAPID	4	3-5 m. or sq. km	4	SEGREGATED OXIDE	4
DEPTH		5-10 m or sq km	5	PEGMATITIC	5
< 0.5 m	1	10-20 m or sq km.	6	NONMETALLIC	6
0.5 - 1 m	2	> 20 m or sq km	7	MINERALIZED FROST HEAVE	7
1 - 2 m	3	**POSITION**		MINERALIZED FLOAT	8
> 2 m	4	INLET	1	OTHER	9
		OUTLET	2		
		OTHER	3		

Figure 8b: Checklist for geochemical data sheet, 1973.

ROUTE/REQUEST FORM

NAME ______________________ GEOLOGIST NUMBER __________ DATE ___/___/___

PROJECT____

KEYPUNCH __________ DATA LIST __________ NOTE LIST __________ DUPLICATE __________

STRUCTURAL TRANSLATES: layering & foliation ______ minor folds & linear structures __________

joints, faults, veins, dykes, sills __________

PETROLOGIC TRANSLATES: rock-type, fabric, relation __________ rock-type, represention, analysis __________

rock-type, minerals __________ representation, analysis, map-unit, specific gravity __________

STEREO PLOTS layering ______ foliation ______ mf axis ______ axial surface ______ lin str ______ joints ______ faults, etc. ______

CHEMICAL ANALYSES meso I ______ meso II ______ cipw ______ other __________________

TERNARY PLOT lineprinter ______ X-Y plotter ______

MAP PLOTS station ______ layering ______ foliation ______ m f axis ______ axial surface ______

linear structures ______ joints ______ faults ______

nw easting __________ nw northing __________ se easting __________ se northing __________

n-s length __________ e-w length __________

title ____

SPECIFIC GRAVITY: calculation card output ______ printer output ______ both ______

error ______

CHI^2 & HISTOGRAM ______

KORZHINSKII PLOT ______

Figure 9: Route Request Form.

Table 1: Utility programs

Mineral Resources Division Program Number	Title of Program	Required Input	Output	Comments
A10C01	80/80 listing	key punched data sheets	80-column undecoded listing	Used to check obvious errors in the punched data
A10C02	Edit program	key punched data file	diagnostic error listing	Ensures that the data recorded is both logical and correct; the errors must be corrected since subsequent processing requires valid data
A10C03	Magnetic tape, structural data	key punched corrected data file	magnetic tape	Permanent data storage for all forms of structural data manipulation
A10C04	Duplicate card deck	key punched corrected data file	80-column punched cards	A second deck is useful for manual manipulation of data
A10C05	Magnetic tape all data	key punched corrected data file	magnetic tape	Program serves as permanent storage for combined structural and petrological data

Table 2: Decoding programs

Mineral Resources Division Program Number	Title of Program	Required Input	Output*	Comments
A10C06	Petrology	output of A10C05	line printer listing	Lists field relations, rock types and fabrics
A10C07	Petrology	output of A10C05	line printer listing	Lists rock types, sample representation and analysis
A10C08	Petrology	output of A10C05	line printer listing	Lists rock types and minerals of note
A10C09	Petrology	output of A10C05	line printer listing	Lists sample representation, analysis, map-unit and specific gravity
A10C10	Structure	output of either A10C05 or A10C04	line printer listing	Lists layering and foliation
A10C11	Structure	output of either A10C05 or A10C04	line printer listing	Lists minor folds and linear structures
A10C12	Structure	output of either A10C05 or A10C04	line printer listing	Lists joints, faults, veins, dykes and sills

*All decoding programs produce printer output which includes: Station number, Geologist number, Year, UTM Cordinates.

Table 3: Line printer plot programs

Mineral Resources Division Program Number	Title of Program	Required Input	Output	Comments
A10C13	Stereographic projections	output of A10C04	Stereographic projection produced on line printer	Plots the number of points counted within a unit area, and the percentage of points within the same unit area
A10C17	Ternary Plot	values of X, Y and Z calculated to 100%	Ternary Plot produced on line printer	Effective for a preliminary study or quick perusal of data

Table 4: Petrological calculation programs

Mineral Resources Division Program Number	Title of Program	Required Input	Output	Comments
A10C14	Meso I	chemical analysis input document	two pages of output: (a) FeO and Fe_2O_3 separate, (b) Fe_2O_3 recalulated to FeO.	Calculated normative mineral assemblages, including hydrous phases, that are developed through amphibolite facies metamorphism; designed to allow the mineral equation to be modified
A10C15	Meso II	same as A10C14	same as A10C14	Calculates normative minerals that are characteristically developed in the hornblende granulite facies or in igneous assemblages with hydrous phases
A10C16	CIPW	same as A10C14	Three pages of output: (a) chemical analysis calculated to 100% with and without H_2O and CO_2 (b) norms and ratios as both weight per cent and molecular percent (c) norms and ratios calculated with ferric and ferrous iron combined as total Fe_2O_3	Included in output are values for Differentiation Index, Normative Colour Index and selected oxide ratios
A10C19	Petrochemical parameters—1	same as A10C14	Listing uses code name for the various parameters	Calculates the following: modified Larsen parameter; $Na^{+}/K^{+}/CA^{+2} + Fe^{+3}/Mg^{+2}$ recalculated to 100; Wager's Iron Ratio; Niggli values; SKM values; Osann values; ACF calculated to 100; Barth's standard cell and molecular norm
A10C20	Petrochemical parameters—2 (Rogers and Le Couter 1966-1970)	same as A10C14	same as A10C19	Calculates the following: Poldervaart's differentiation parameters; CIPW norm (anhydrous); percentage composition of normative minerals; Thornton and Tuttle's differentiation index; Poldervaart and Parker's crystallization index; Wager's albite ratio; Von Wolff parameters
A10C31	Mode-oxide percentages	same as A10C14	(a) listing of relative oxide quantities; (b) 80-column punched card formatted for input to A10C14-16	Approximates oxide percentages from modal analysis; mineral compositions are defined in the program by "composition" cards which can be changed to better comply with observed petrographic characteristics (i.e. An/Ab ratios)

Table 5: X-Y pen plot programs

Mineral Resources Division Program Number	Title of Program	Required Input	Output	Comments
A10C18	Aerial distribution maps	key punched corrected data file	a map produced on the CalComp X-Y drum plotter	Plotting is based on the UTM grid, scale of plotting has to be defined for each map
A10C30	Stereographic projection	same as A10C18	uncounted and uncontoured Schmidt net projection on the CalComp X-Y drum plotter	Radius of the net, parameter to be plotted (i.e. layering etc.), and symbol (122 available) used to represent the point must as defined
A10C22	Cartesian coordinates	X-Y variation data sheet	X versus Y diagram of two components on a rectangular grid	
A10C26	Histogram	Bar plot data sheet	Produces a bar-diagram or histogram	Each bar may be composed of up to four variables
A10C28	Korzhinskii plot (Korzhinskii, 1959)	Korzhinskii data sheet	Right angle triangle based plot of multi-component systems	
A10C29	Ternary Plot	Pen plotter ternary data sheet	Ternary plot and a listing of the components plotted recalculated to 100 per cent	Each component may be composed of four individual elements
A10C32	X-Y variation curve	same as A10C22	X-Y variation diagram with a best-fit curve	Curve is calculated using least squares criteria for each of the X-Y pairs

Table 6: Mathematical programs

Mineral Resources Division Program Number	Title of Program	Required Input	Output	Comments
A10C24	Specific gravity	specific gravity data sheet	line printer listing, 80-column punched card or both	
A10C25	Specific gravity errors	punched output of A10C24	line printer listing	Reweighed-sample data must be supplied for the error calculation
A10C27	Joint frequency histogram	output of A10C03	line printer histogram	Calculates Chi^2, the confidence of occurrence
A10C33	Ellipse calculation	A = the major axis B = the minor axis	line printer listing	Used to calculate refractive indices for various minerals
A10C21	Calculation of the angle θ	output of A10C03	line printer listing of correspondence numbers	Calculates θ, the angle between the azimuths of the foliation and fold axis

adopted as the basis for assigning unique mnemonic codes. A list of codes currently in use by the Mineral Resources Division is given in Appendix III.

Ranking of letters for the "Franklin Method"

1. A	4. O	7. H	10. T	13. R	16. C	19. G	22. B	25. J
2. E	5. U	8. Y	11. N	14. L	17. M	20. P	23. V	26. Q
3. I	6. W	9. one double	12. S	15. D	18. F	21. K	24. X	27. Z

Rules for Coding

1. First letter of each word is never deleted.
2. Delete letters from right to left, in above order.
3. Delete only one letter in double letter occurrences.
4. Continue deletion until code word reduced to predetermined size.
5. Words already smaller than predetermined size are padded with blank notations to complete the code.
6. Blanks always occur on the right.
7. Names should be coded in alphabetical order. Where the code word matches a predetermined code word the first word has precedence. The second code is adjusted by deleting the last letter included in the code and substituting the letter deleted immediately prior to formation of the code word. This procedure is continued until a unique code is obtained.

Discussion

The selection of qualitative and quantitative parameters for the description of basic structural, petrologic and chemical entries is critical in the development of field and laboratory data sheets. Users of the sheet must agree on the definition and scope of all parameters to maintain consistent and standardized observations. Strict adherence to terms that are standard to accepted authoritative geological references can only partially alleviate the above problem. For the data file to be usable it is also essential to conduct periodic revision of parameters as classifications evolve together with an accompanying update of previous data.

Three functional conventions provide a basis for many geologic data files:

(a) right justified numerics as station numbers;

(b) geographical grid identifying the station positions (i.e. U.T.M.);

(c) strikes of planar features recorded as three digit azimuths with dips to the right (including dips >90°).

Once instituted all must be retained throughout the life of the data bank. Any revision of these standards necessitates a complete update of the data file, which is both time consuming and expensive.

It is absolutely essential, if the full potential of these procedures is to be realized, that the geologist be completely familiar with the data sheets and the capabilities of the computer programs available for data processing. The geologist must also instruct his assistants in the use of the data sheets and maintain standards within the project's data files. Periodic verification of the data sheets in the field is esential. This verification should eliminate the three most common errors of:

(a) missing sheet identification code;

(b) illegible mnemonic codes;

(c) partial quantitative readings.

It has been the authors' experience that in excess of 80% of the errors fall into the first two categories. These errors are flagged by program A10C02 (Table 1) and are thus easily detected even after keypunching. A far more serious error is that of partial readings in the structural data. As FORTRAN does not recognize the distinction between 0 (zero) and blanks it is imperative that only complete orientation readings are entered. For example, in the case where only the trend of the foliation is apparent and the dip not measurable, entering the trend under strike and leaving the dip blank will cause the computer to generate a horizontal dip which will be used in subsequent calculations. The same problem, where a reading is not properly right justified, is exceedingly dangerous and is usually not detected once the data is keypunched because the format is acceptable to program A10C02 (Table 1).

One of the persistently annoying problems inherent in this type of data acquisition is the inevitable delay of transferring data from the field sheet to keypunched cards. Two factors appear to be mainly responsible for the delays:

(a) large volumes of data are submitted for keypunching at the same time (i.e. the end of the field season);

(b) staffing of the keypunching section of the Manitoba Government is geared for a steady and constant flow of data thus unusually bulky single jobs have low priority.

To resolve this problem several solutions were examined. Carbon copies of data sheets in the field were not implemented because of the high cost of "self-carboning" sheets and because of the high "nuisance" value of carbon papering the field sheets on the outcrop. Photographic copying of the sheets in the field was found to be impractical. Dispatching the accumulated sheets periodically also caused problems because of the danger of loss incurred during transit. Although expensive, "farming-out" of keypunching may be the best solution; this has not yet been thoroughly tested.

The arguments in favor of adopting field sheets with computer processible format are usually based on mechanical storage, recall and manipulative capabilities of the system. It is, however, equally important to stress the vastly improved qualitative and quantitative aspects of the collected data itself. This improved organization allows rapid collection and manual manipulation of large volumes of data and at the same time maintains the quality and completeness of data from each station at the required level of sophistication.

Past Performance

From its inception in 1966, data sheets have undergone continuous updating. In nine years the data file has grown to nearly 100,000 stations, each containing up to 114 individual data entries (Table 7). The competent use of the data sheet has led to more consistent and complete record of information from each station. Due to standardization of geologists' definitions and to some extent, classifications, the data are applicable not just in restricted areas mapped by individuals but may be easily used in compiling large tracts mapped by users of the system.

1974 Field Document Design

In keeping with our policy for continually reviewing and updating the field data sheets in the light of ongoing experience, the 1974 format (Figure 3a) exhibits the following new features:

1) Diversification of entry types into:
   a) coded for routine keypunching;
   b) coded for data consistency, manual retrieval and *ad hoc* keypunching;
   c) project options, to allow for coding of non-universal parameters peculiar to individual project objectives;
   d) notes for manual or machine retrieval.
2) Expansion of foliation categories to allow for up to two readings per data sheet.
3) Removal of joints and fabric to coded non-keypunched section.
4) Addition to average layer/unit thickness category.
5) Expansion of sample analysis category.
6) Addition of grain size record to coded — not keypunched section.
7) Expansion of checklist parameters.

It was recognized at an early stage in the development of the data recording procedures that there was a definite need for flexibility in the organization of the input documents to make the system as compatible as possible, with individual geologists' field practises. Accordingly two compatible docu-

Table 7: Progress of Mineral Resources Division computer data file

Year	Number of Projects	Number of Users	Size of annual data file (stations)	Size of total data file (stations)
1966	1	9	5,000	5,000
1967	1	9	6,500	11,500
1968	4	13	7,500	19,000
1969	4	13*	12,000	31,000
1970	4**	16	10,900	41,900
1971	5	15	17,000	58,900
1972	7	17	18,150	77,050
1973	4	12	12,700	89,750
1974	8	9	7,400	97,100

*The practice of assigning individual geologist numbers to seasonal assistants was abandoned in 1969. The number of users subsequent to 1969 represents only geologists permanently attached to the Minerals Resources Division.

**In 1970 preliminary studies for two new projects were undertaken. Although the data acquired is included in the size of the data file, the preliminary studies have not been included in the total number of projects.

ments are again provided, an 8½" x 11" size with checklist included and a smaller 7" x 5" document for use with separate flip chart checklist.

Future Developments

Ongoing revisions and improvements are inherent in the concept and essential to the development of any ordered data gathering methodology. Not only will the existing Manitoba field documents undergo additional changes in content and format, but it is hoped that new documents will be designed to cover all other aspects of the department's geological operations. In this way it should then be possible to merge the data from a number of different files, giving rise to a truly economic and functional data base management system. Only with this sort of capability can we begin to regain the ability for overviewing regional problems based on a balanced appraisal of large numbers of interdependent data. To this end a move has already been made by UNESCO in sponsoring a world-wide appraisal of data base management systems. Details of the current status of the appraisal may be found in Hutchinson, 1974. It must be hoped that when a system truly designed to geologic or earth science applications is made available that the bulk of the data in hand is structured and defined with sufficient rigidity to be processed with reliability.

The recent acquisition by the Manitoba Surveys Branch of a digitizer provides yet another avenue for further refining the exiting data handling procedures. Initial attempts at defining or correcting station coordinates using the digitizer have led to most promising savings in time and increase in accuracy. The development of a fully automated cartographic capability is viewed as an eventual consequence of our current activities but must of course reach a point where the current high costs can be justified on an integrated user basis by the department.

Acknowledgements

The continuing development of the system benefitted from criticism and suggestions from the staff of the Mineral Resources Division. The authors especially thank Heinz Ambach for his suggestions, many of which led to substantial improvements in communications between the geologist and the computer. J. F. Stephenson designed the geochemical data sheet.

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Appendix I
Description of the Combined Structural and Petrologic Data Sheet (1974 Format)

N.B. Due to an inadvertent compiling error columns 74-80 on the structural sheet and columns 72-80 on the petrologic sheet of the 5" x 7" format are not compatible with those on the 8½" x 11" format. This situation will be corrected in 1975.

The current structural and petrologic data sheets are shown in Figures 3a and 3b. The reference section is located across the top of the combined sheet giving the identification and geographic location of the point under observation. The remainder of the sheet is divided into two major vertical panels, one containing structural data, the other petrologic data. The major panels are subdivided into columns for coding descriptive terms, quantitative and qualitative data.

The structural input document is constructed with space for recording only single observations on each of the various structural elements excepting foliations. Additional observations on the same outcrop will require the use of additional data sheets and, therefore, additional computer cards. For example, if it is required to record the attitudes of three veins, this will lead to three cards for which the reference information in columns 1-20 will be identical and the sheet identification in column 80 will vary in sequence. Thus it will always be possible to identify these three cards as belonging to the same site. The use of Project Options is discussed in dealing with the details of the petrological data sheet.

Two rock units may be coded on each petrologic sheet with the convention of recording the major unit in column 1. More than one sheet must be used of three or more rock units and recorded. Up to four sheets are allowed. These are consecutively coded 6-9 under sheet identification (column 80). This allows the coding of up to 8 separate rock units in 8 columns. On the second and subsequent sheets the columns are automatically machine designated in numeric sequence (thus on sheet 7, columns 3-4, sheet 8, columns 5-6, etc.).

Reference Section (columns 1-20)

Each geologist is allotted a two digit code (columns 5, 6) which he retains permanently (i.e. 01, 02). Each station in the field (this may be a single outcrop or part of a large outcrop area) is identified by successive numbers 1-9999 entered right justified in columns 1-4. These numbers may be repeated from year to year, but are identified for any one year in column 7. (The remaining 3 digits for the year are added in programming for output). For each geologist this station number will also serve as a page number for the data sheet, so that reference can readily be made to original notes.

Universal Transverse Mercator (U.T.M.) grid coordinates are used for documenting station locations (columns 8-20). The U.T.M. zone identification letters are added in programing.

Structural Data (columns 22-79)

The check list (Figure 3c) contains lists of qualifying categories and parameters for each of the principal structural elements together with their corresponding codes. Coding allows all descriptive terms to be represented numerically on the data sheet. All coded input on the structural data sheet is numeric but the use of 0 (zero) as a code has been avoided, as FORTRAN does not distinguish (in the I, F, D and E formats) between 0 and blanks.

The coding/input document contains all numerical data for the various structural element including the attitudes of planar and linear structures, and the numerical codes referring to the descriptive terms. All attitudes of planar structural elements are recorded as azimuths of the strike directed so as to place the dip direction to the right (i.e. a plane striking due south with a dip of 60° to the west would be recorded as 180/60. 360/60 would indicate a plane with a parallel strike but with a dip to the east). For layers in which diagnostic tops can be determined, overturning of beds is recorded by using the same convention but noting the supplement of the observed dip. Thus the attitude of an overturned bed with a strike of 180 dipping 60 east would be recorded as 180/120. (Where two structural elements, e.g. layering and foliation, are parallel, the same attitude will be recorded for both).

Petrologic Data (columns 22-70)

The petrologic data sheet is used in conjunction with a check list containing the list of qualifying categories, coded parameters and a subsidiary list of derived mnemonics. The petrologic data sheet in its present format requires numeric (columns 30-33, 35-37, 39-41, 54-57, 68 and 71), alphameric coding (22-29, 34, 38, 42-53, 58-65, 66-67, 69-70 and 78-79) with columns 72-77 remaining optional.

The categories of data which form the basis of this sheet are self-explanatory and except for the following exceptions do not require further discussion:

(a) Sample Representation (columns 54-57)

This category serves a dual purpose and is only utilized if samples are collected at a station. It is used to assign a unique sample number and to identify the type of sample collected.

A coded entry (as specified on the check list) in any one of the columns causes the computer to automatically generate the sample number. This number consists of four elements:

(i) station number (columns 1-4)

(ii) geologist number (columns 5-6)

(iii) year (column 7)

(iv) sample number (columns 46-51)

A machine generated sample number takes a i-ii-iii-iv format (i.e. 25-4-1309-1A). The last digit consists of a hybrid numeric and alphameric number. The numeric portion is derived from the generated numeric designation 1-8 of the rock-type column that the sample is coded in. Thus rock-type 3 will have a corresponding sample even if rock-types 1 and 2 were not sampled. The alphameric generated is either 'A' or 'B' designating the sample as the first or second sample of the particular rock unit. If more than two samples of the same rock-type are required, box 21 of coded notes may be activated.

(b) Minerals of Note (column 42-53)

This section is used in conjunction with the mnemonic check lists and may be utilized in three ways:

(i) to code minerals that are critical for classifications used on the project;

(ii) to code minerals that are critical for the definition of metamorphic isograds;

(iii) to code the three most abundant minerals in a rock.

(c) Map-Unit (columns 66-71)

Map-unit numbers are not inserted in the field unless a geologic classification for the project-area exists. In practice classifications evolve as the mapping progresses thus it has been the author's experience that map-units are best inserted after the mapping is concluded.

(d) Project Options (columns 72-77)

These options are inserted to allow coding which is unique to individual geologists or group of geologists. Its function is dependent on the individual users, but it is suggested its uses be for rapid manual or machine sorting of the data.

(e) Map or Subarea (columns 78-79)

This option is designed to allow rapid sorting of data by designated geographic or geological areas.

Sheet Identification (column 80)

The sheet identification serves two functions:

(a) it allows machine recognition and separation of structural and petrologic data (codes 1-5 are exclusive for structural data; codes 6-9 for petrologic data);

(b) it is used for pagination in case of multiple entries requiring the use of more than one data sheet on one outcrop.

Coded Notes (column 21)

It is possible to have notes handled directly by the computer. On the data sheets such notes must be written length-wise in the 'coded notes' section of the grid panel on the sheet. These notes are then written in alphameric characters in columns 21-80 of a punched card with columns 1-20 being the identification. The number of such 'note' cards must be entered in column 21 of either the preceding structural or petrologic data card depending on the relevant subject of the notes.

In the present programing up to four such 'note' cards (i.e. 240 alphameric characters) are allowed per page. Taking into consideration that up to five pages under structure and up to four pages under petrology can be used per station, in reality 2160 alphametric characters are allowed per station.

Normally, column 21 of the data card is left blank. A number 1 to 4 in this column will instruct the computer to read the following 1, 2, 3 or 4 cards specified as alphameric data, and to reproduce these notes with the rest of the output. Codes higher than 4 in the optinal column 21 have been reserved for any future modification or additions to the system.

APPENDIX II
Description of the Geochemical Field Data Sheet

The main part of the data sheet (Figure 8a) comprises a 'Sample Data' section and 'Collection Site Data' section. The former deals with the descriptive aspects of the sample whereas the latter is coded for information in the environment in which the sample was collected. The parameters selected in columns 21-80 are intended to cover only those types of geochemical surveys and environments that will be encountered in Manitoba.

The section at the top of the data sheet dealing with station identification (columns 1-7) and location, using the Universal Transverse Mercator (U.T.M.) grid system (columns 8-20), is completed in a manner similar to that for the structural and petrological field data sheets. The sections headed 'Sample data' and 'Collection site data' are completed in the appropriate subsections by referring to the coding in the 'Geochemical Field Data Checklist' (Figure 8b).

Sample Data Section

Specific information relating to the description of the collected sample(s) at each station will be entered in coded form in this section. The sample media is first defined (column 21) and this remains the same for all sample stations in a given geochemical survey. If two or more sample media are collected a different data sheet is used for each. Samples collected of glacial surficial deposits or natural water may be further subdivided on the basis of their physiographic origin (Columns 31 and 32).

Physical characteristics of glacial drift, soil or sediment, including 'texture or type' (columns 22 and 23) and colour (columns 24 and 25) are specified in the field. A simplified standard notation of soil horizons fixes the relative positions of soil samples (columns 33 and 34). The actual depths of soil, glacial drift and sediment samples below the surface is recorded in metres or centimetres (43-48). The visual appearance of water samples, i.e. 'Turbidity' (column 26) and 'Colour' (column 27) can be recorded on a scale of 1 to 9 on a comparative basis. This may be carried out by grouping a series of water samples in thin translucent plastic containers and visually comparing them with 'standards' having the full range of turbidity and degree of colouration selected from the sample population. Provision is made for recording 2 organs of a single species of vegetation per sheet (columns 35 to 37).

Bedrock outcropping in the immediate vicinity of the sample station is recorded by utilizing the four-letter petrologic mnemonic code (Franklin method) for rock names. Space is provided for a major and minor rock type (columns 49 to 56). Recognizable rock fragments of residual or transported origin occurring with surficial sample material may be coded in the same way (columns 57-60).

A maximum of nine lines of coded notes may be accommodated per data sheet. Where necessary the number of coded lines is numerically indicated (column 72), although normally this box is left blank and the notes serve merely as a record. The number of samples themselves will be individually numbered. A single box remains for the coding of miscellaneous data (column 74).

Collection Site Data Section

Relevant environmental factors affecting the nature of the geochemical sample are recorded in this section. For surficial geochemical surveys, including glacial drift, soils, and vegetation sampling, the dominant vegetation type, relief and drainage conditions are parameters that can be routinely recorded at each station (columns 28, 29, 30). Where natural waters and sediments are being collected in streams, rivers and lakes, provision is made for coding flow rate (column 38), depths (for sediments, column 39) and width of channel or area of water body (column 40). The location of lake sample sites relative to its drainage system is also coded (column 41). Various types of mineralization that may be encountered can be coded for quick reference (column 42) although additional notes would be included below. Notable minerals which may or may not be of economic interest can be recorded by using the two-letter mnemonic code (Franklin method).

Simple field tests, including temperature and pit measurements, carried out in certain geochemical surveys such as water sampling, may be reported to the nearest degree and tenth of pH unit (columns 65-68). Provision is also made for mesurements rarely performed in the field such as Eh, total heavy metal or specific heavy metal determinations (columns 69-71). The azimuth of glacial striations can be recorded where applicable (columns 75-77).

The last box on the data sheet (column 80) provides for sheet identification if more than one is used for sample station. The use of two or more data sheets at each station will occur when more than one medium is being sampled and/or when the number of samples collected exceeds the number that can be accommodated on each sheet.

APPENDIX III
MNEMONIC CODES

ROCKS

Acidic crystal tuff	ACTF
Acidic lapilli tuff	ALTF
Acidic volcanic breccia	AVBC
Acidic volcanic flow	AVFL
Acidic pebble agglomerate	APAG
Acidic pebble breccia	APBC
Acidic pillowed volcanic flow	APVF
Acidic boulder agglomerate	ABAG
Acidic boulder breccia	ABBC
Acidic cobble agglomerate	ACAG
Acidic cobble breccia	ACBC
Actinolite schist	ACSC
Adamellite	ADML
Adamellitic gneiss	AMGS
Agmatite	AGMT
Alaskite	ALSK
Amphibolite	AMPB
Anatexite	ANTX
Anatexite (arkosic restite)	AXAK
Anatexite (greywacke restite)	AXGK
Andesite	ANDS
Anorthosite	ANRS
Anorthositic gabbro	ARGB
Argillite	ARGL
Arkose	ARKS
Arkosic gneiss	AKGS
Arterite	ARTR
Basalt	BSLT
Basic crystal tuff	BCTF
Basic volcanic breccia	BVBC
Basic volcanic flow	BVFL
Basic boulder agglomerate	BBAG
Basic boulder breccia	BBBC
Basic cobble agglomerate	BCAG
Basic cobble breccia	BCBC
Basic pebble agglomerate	BPAG
Basic pebble breccia	BPBC
Biotite gneiss	BTGS
Biotite schist	BTSC
Boulder flow breccia	BFBC
Calcarenite	CLCR
Calc-silicate rock	CLCC
Cataclasite	CCLS
Charnockite	CRCK
Chert	CHRT
Cobble flow breccia	CFBC
Chlorite schist	CLSC
Conglomerate	CGLM
Cordierite gneiss	CDGS
Dacite	DCIT
Diabase	DIBS
Diatexite	DTXT
Diatexite (arkosic restite)	DXAK
Diatexite (greywacke restite)	DXGK
Diopside gneiss	DPGS
Diorite	DORT
Dolomite	DLMT
Dunite	DUNT
Feldspar porphyry	FPPP
Feldspar quartz porphyry	FQPP
Feldspathic greywacke	FPGK
Feldspathic sandstone	FPSD
Flaser gneiss	FLGS
Gabbro	GBBR
Garnetiferous amphibolite	GFAB
Gneiss layered	GSLD
Gossan	GSSN
Granite	GRNT
Granite gneiss	GCCS
Granodiorite	GRDR
Granodioritic gneiss	GDGS
Granulite	GRNL
Granulite pyroxene	GLPX
Greywacke	GRCK
Grit	GRIT
Hornfels	HRFL
Hypersthene gneiss	HPGS
Intermediate crystal tuff	ICTF
Intermediate lapilli tuff	ILTF
Intermediate volcanic flow	IVFL
Intermediate volcanic breccia	IVBC
Intermediate volcanic flow, pillowed	IVFP
Intermediate boulder agglomerate	IBAG
Intermediate boulder breccia	IBBC
Intermediate cobble agglomerate	ICAG
Intermediate cobble breccia	ICBC
Intermediate pebble agglomerate	IPAG
Intermediate pebble breccia	IPBC
Iron formation	IRFM
Limestone	LMSN
Lithic greywacke	LCGK
Marble	MRBL
Marl	MARL
Meta-arkose	MTAK
Meta-gabbro	MTGB
Meta-greywacke	MTGK
Metasediment	MTSM
Metatexite	MTTX
Metatexite (arkosic restite)	MXAK
Metatexite (greywacke restite)	MXGK
Mica schist	MCSC
Migmatite	MGMT
Monzonite	MNZN
Mylonite	MLNT
Nebulitic granite	NBGR
Norite	NORT

Orthoquartzite	ORQZ
Oligomictic boulder conglomerate	OBCG
Oligomictic boulder breccia	OBBC
Oligomictic boulder agglomerate	OBAG
Oligomictic cobble conglomerate	OCCG
Oligomictic cobble breccia	OCBC
Oligomictic cobble agglomerate	OCAG
Oligomictic pebble conglomerate	OPCG
Oligomictic pebble breccia	OPBC
Oligomictic pebble agglomerate	OPAG
Paragneiss	PGNS
Pebble flow breccia	PFBC
Polymictic pebble agglomerate	PPAG
Polymictic pebble breccia	PPBC
Polymictic pebble conglomerate	PPCG
Polymictic cobble agglomerate	PCAG
Polymictic cobble breccia	PCBC
Polymictic cobble conglomerate	PCCG
Polymictic boulder agglomerate	PBAG
Polymictic boulder breccia	PBBC
Polymictic boulder conglomerate	PBCG
Pegmatite	PGMT
Pelitic gneiss	PCGS
Peridotite	PRDT
Picrite	PCRT
Pillowed andesite	PDAD
Pillowed basalt	PDBL
Pillowed dacite	PDDC
Polymict breccia	PMBC
Polymict volcanic breccia	PVBC
Protoquartzite	PRQZ
Psammitic gneiss	PMGS
Psephitic gneiss	PPGS
Pyroxene amphibolite	PXAB
Pyroxene gneiss	PXGS
Pyroxenite	PRXN
Quartz monzonite	QZMZ
Quartzite	QRTZ
Rhyodacite	RDCT
Rhyolite	RYLT
Sandstone	SNDS
Serpentinite	SRPN
Semîpelitic gneiss	SPGS
Shale	SHLE
Siltstone	SLSN
Skarn	SKRN
Subgreywacke	SBGK
Syenite	SYNT
Sedimentary quartzite	SMQZ
Tonalite	TNLT
Tonalitic gneiss	TCGS
Trachyandesite	TRCS
Trachyte	TRCT
Ultrabasic	ULBC
Ultramylonite	ULML
Ultramafic	ULMF
Veined gneiss	VDGS
Venite	VNIT

MINERALS

Amphibole	AB
Actinolite	AC
Andalusite	AD
Augite	AG
Ankerite	AK
Allanite	AL
Anthophyllite	AN
Apatite	AP
Arsenopyrite	AR
Biotite	BO
Beryl	BR
Carbonate	CB
Calcite	CC
Cordierite	CD
Chloritoid	CH
Chlorite	CL
Chalcopyrite	CP
Chromite	CR
Copper sulphide	CS
Clinopyroxene	CX
Clinozoisite	CZ
Dolomite	DM
Diopside	DP
Epidote	EP
Fuchsite	FC
Fluorite	FL
Glaucophane	GC
Galena	GL
Graphite	GP
Garnet	GR
Grossularite	GS
Hornblende	HB
Hematite	HM
Hypersthene	HY
Idocrase	ID
Iddingsite	IG
Ilmenite	IM
Kyanite	KN
Limonite	LM
Leucoxene	LX
Microcline	MC
Magnetite	MG
Molybdenite	ML

Mesoperthite	MP
Muscovite	MV
Orthoclase	OC
Olivine	OV
Orthopyroxene	OX
Prehnite	PE
Potash feldspar	PF
Plagioclase	PG
Pyrrhotite	PH
Pyralspite	PL
Penninite	PN
Pyrophyllite	PO
Phlogopite	PP
Perthite	PR
Pinite	PT
Pyroxene	PX
Pyrite	PY
Quartz	QZ
Riebeckite	RB
Rutile	RL
Scapolite	SC
Sphalerite	SH
Spinel	SL
Sillimanite	SM
Sphene	SN
Stilpnomelane	SO
Serpentine	SP
Sericite	SR
Staurolite	ST
Silica cryptocrystalline	SY
Talc	TC
Tourmaline	TL
Tremolite	TM
Uralite	UL
Zircon	ZC
Zoisite	ZS