SKB TECHNICAL REPORT 88-06

# Description of geological data in SKBs database GEOTAB

Tomas Stark

Swedish Geological Co, Luleå

April 1988

**SVENSK KÄRNBRÄNSLEHANTERING AB**

*SWEDISH NUCLEAR FUEL AND WASTE MANAGEMENT CO*

BOX 5864 S-102 48 STOCKHOLM

TEL 08-665 28 00 TELEX 13108-SKB

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Information on KBS technical reports from 1977-1978 (TR 121), 1979 (TR 79-28), 1980 (TR 80-26), 1981 (TR 81-17), 1982 (TR 82-28), 1983 (TR 83-77), 1984 (TR 85-01), 1985 (TR 85-20), 1986 (TR 86-31) and 1987 (TR87-33) is available through SKB.

SWEDISH GEOLOGICAL CO
Division of Engineering Geology
Client: SKB

REPORT
ID-no: IRAP87063
Date: 1988-04-08

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# IN SKB´S DATABASE GEOTAB

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# 1 INTRODUCTION

Since 1977 the Swedish Nuclear Fuel and Waste Management Co, SKB, has been performing a research and development programme for final disposal of spent nuclear fuel. The purpose of the programme is to aquire knowledge and data of radioactive waste. Measurements for the characterisation of geological, geophysical, hydrogeological and hydrochemical conditions are performed in specific site investigations as well as for geoscientific projects.

Large data volumes have been produced since the start of the programme, both raw data and results. During the years these data were stored in various formats by the different institutions and companies that performed the investigations. It was therefore decided that all data from the research and development programme should be gathered in a database. The database, called GEOTAB, is a relational database. It is based on a concept from Mimer Information Systems, and have been further developed by Ergodata. The hardware is a Vax 750 computer located at KRAB (Kraftverksbolagens Redovisningsavdelning AB) in Stockholm.

The database comprises four main groups of data volumes. These are:

- Geological data
- Geophysical data
- Hydrogeological data
- Hydrochemical data

In the database, background information from the investigations and results are stored on-line on the VAX 750, while raw data are either stored on-line or on magnetic tapes.

This report deals with geological data and describes the dataflow from the measurements at the sites to the result tables in the database. All of the geological investigations were carried out by the Swedish Geological Survey, before 820701, and by Swedish Geological Co, SGAB, after that date.

The geological investigations have been divided into three categories, and each category is stored separately in the database. They are:

- Surface Fractures
- Core Mapping
- Chemical Analyses

At SGU/SGAB the geological data were stored on-line on a PRIME 750 mini computer, on microcomputer floppy disks or in filed paper protocols. During 1987 the data files were transferred from SGAB to datafiles on the VAX computer. The data from the protocols were punched to data files either on the PRIME (before the transfer) or on the VAX. The flyleafs (tables containing background data) were also punched, transferred and loaded into the database.

In the following chapters the data flow of each of the three geological information categories are described separately.

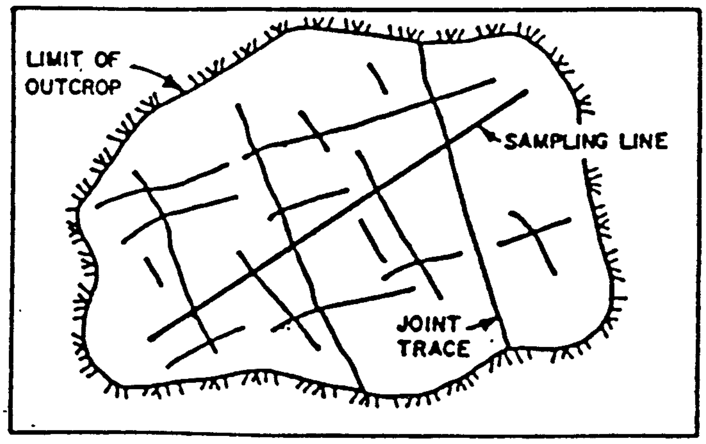
## 2 SURFACE FRACTURES

When studying the qualities of the bedrock at the SKB study sites, information about small fractures in outcrops have been systematically collected. More than 10 sites spread all over Sweden have been investigated. Investigations done after 1981 at the study sites Fjällveden, Gideå and Kamlunge have been stored in a fracture database at the Swedish Geological Co and further processed with computer programs. For earlier study sites such as Sternö, Kynnefjäll, Finnsjön, Svartboberget, Taavinunnanen, Gunnarsdjupträsk, Kärkejaure and Vittangi, information is only available as hand-written forms.

See Figure 2.6 for a description of the surface fractures dataflow.

### 2.1 ACQUISITION OF SURFACE FRACTURE DATA

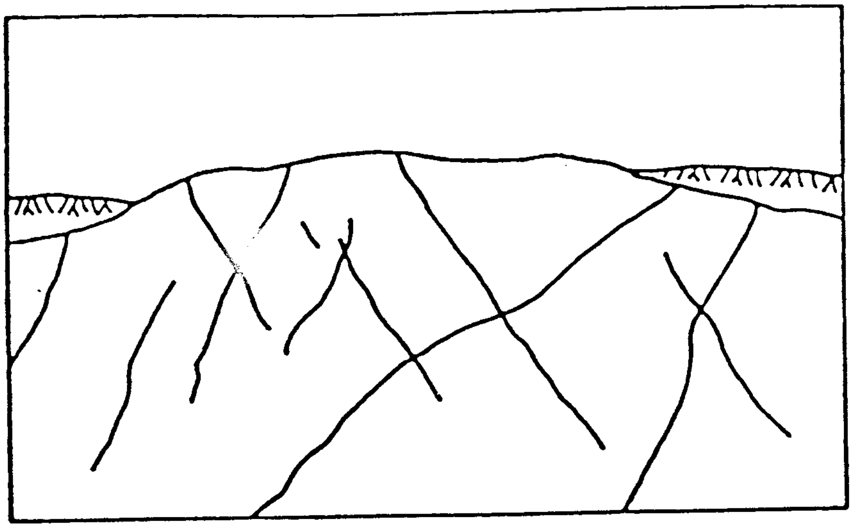
The spatial distribution of fractures measured when performing a linesampling survey on an outcrop gives the frequency of all fractures crossing a scan-line (see Figures 2.1 and 2.2). It gives information of anomalous fracturing, but the number is often strongly biased (Tire´n 1986).




Intersections of joints with outcrop in plan view. Note that longer joint traces have a higher probability of intersecting sampling line than do shorter traces.

**(Beacher 1983)**

Figure 2.1



Profile view of joints intersecting an outcrop. Note that larger joints have a proportionately greater probability of striking outcrop than do small joints. (Beacher 1983)

Figure 2.2

The method used for representing fracture information in the SKB study site program is based on a proposal (Ahlbom 1980) using an orthogonal configuration of two sampling lines (Figure 2.3). The fracture number is here defined as the frequency of intersections between the fractures and the sampling lines irrespectively of the orientation of the fractures. This method has a relatively good reproducibility and is rather fast operating (Tire´n 1986 and Ahlbom 1980).

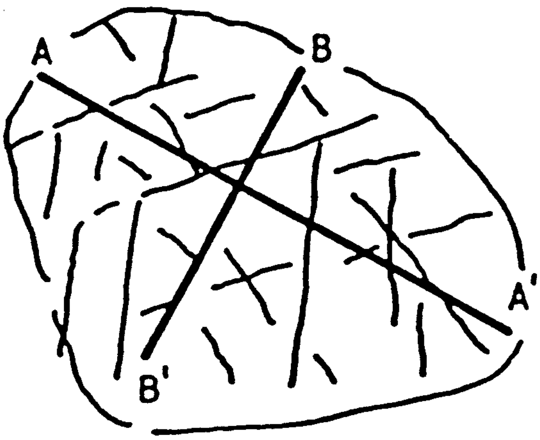



Figure 2.3. Sampling line configuration on an outcrop.

Sampled data is written on forms (see Appendices A-1 to A-5), and later punched and stored into a MIMER database on the PRIME mini computer at SGAB in Luleå.

The forms contain the following information:

Area information

- Area code
- Map sheet number
- Area name
- Y RAK coordinate
- X RAK coordinate

Measuring cross data

- Area code
- Cross number
- Y RAK coordinate
- X RAK coordinate
- Sampling line A
    - orientation
    - length (in meters)
- Sampling line B
    - orientation
    - length (in meters)
- Rock code (see Appendix C-2)

Fracture data

- Area code
- Cross number
- Sampling line (A or B)
- Order number
- Strike
- Dip
- Number of fractures
- Type of fracture (open, sealed, closed or combinations of these)
- Width (in mm)
- Length (in meters)

- Character, minerals (see Appendix C-1)

Structural data

- Area code
- Cross number
- Order number
- Element (eq lineation, axial plane etc)
- Strike
- Dip

Comments

- Area code
- Cross number
- Order number
- Comment text

## 2.2 PROCESSING OF SURFACE FRACTURE DATA

A fracture analysis program including features such as:

- Fracture grouping
- Fracture frequency calculation
- Gefüge diagram
- Rosette diagram
- Parameter discrimination
- Dip/fracture plot

has been used for the processing of surface fracture data. Figure 2.4 is a flow chart for the Fracture Analysis System. Figure 2.5 shows an example of rosette diagrams generated with the Fracture Analysis System.

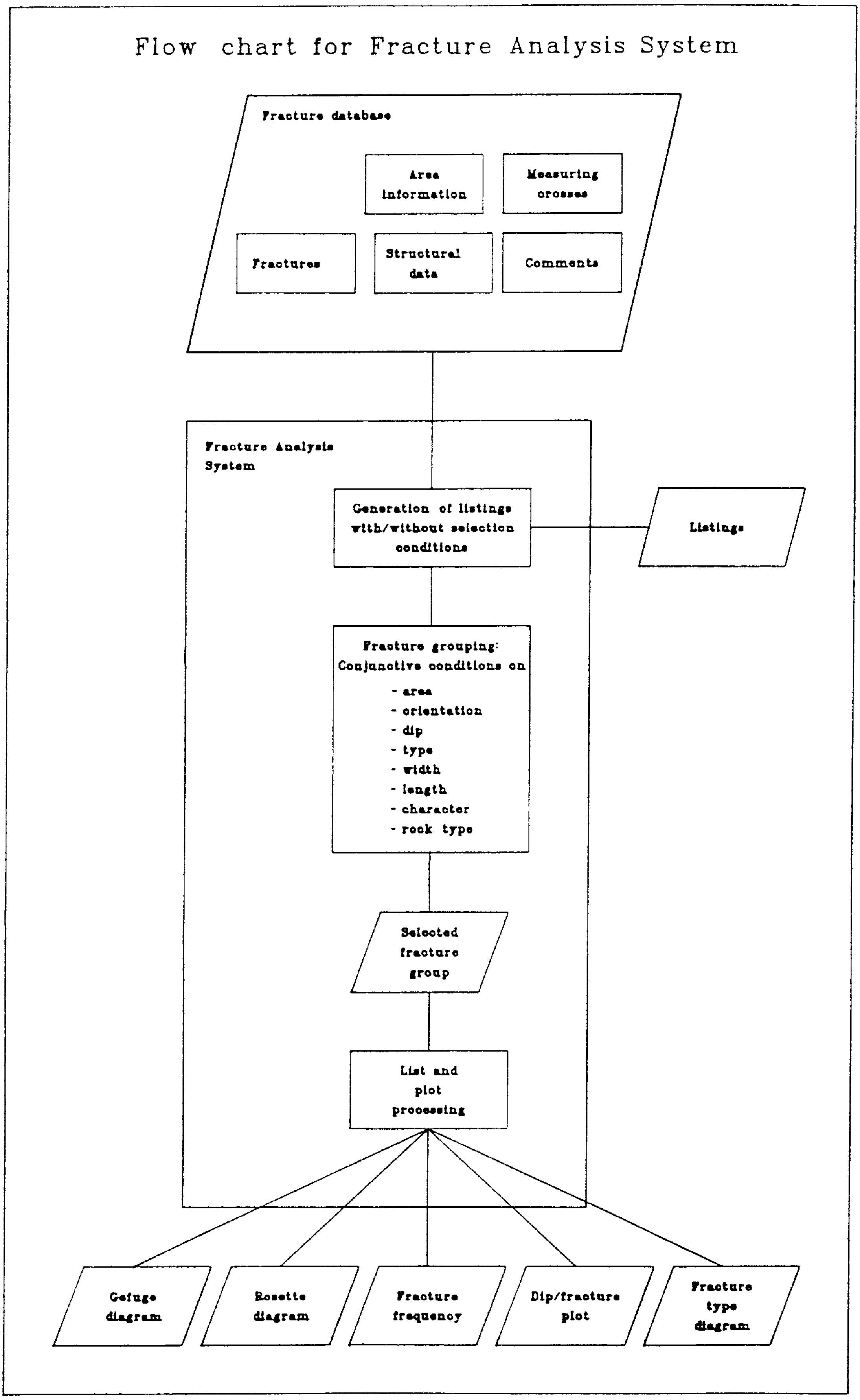



Figure 2.4 Flow chart for Fracture Analysis System

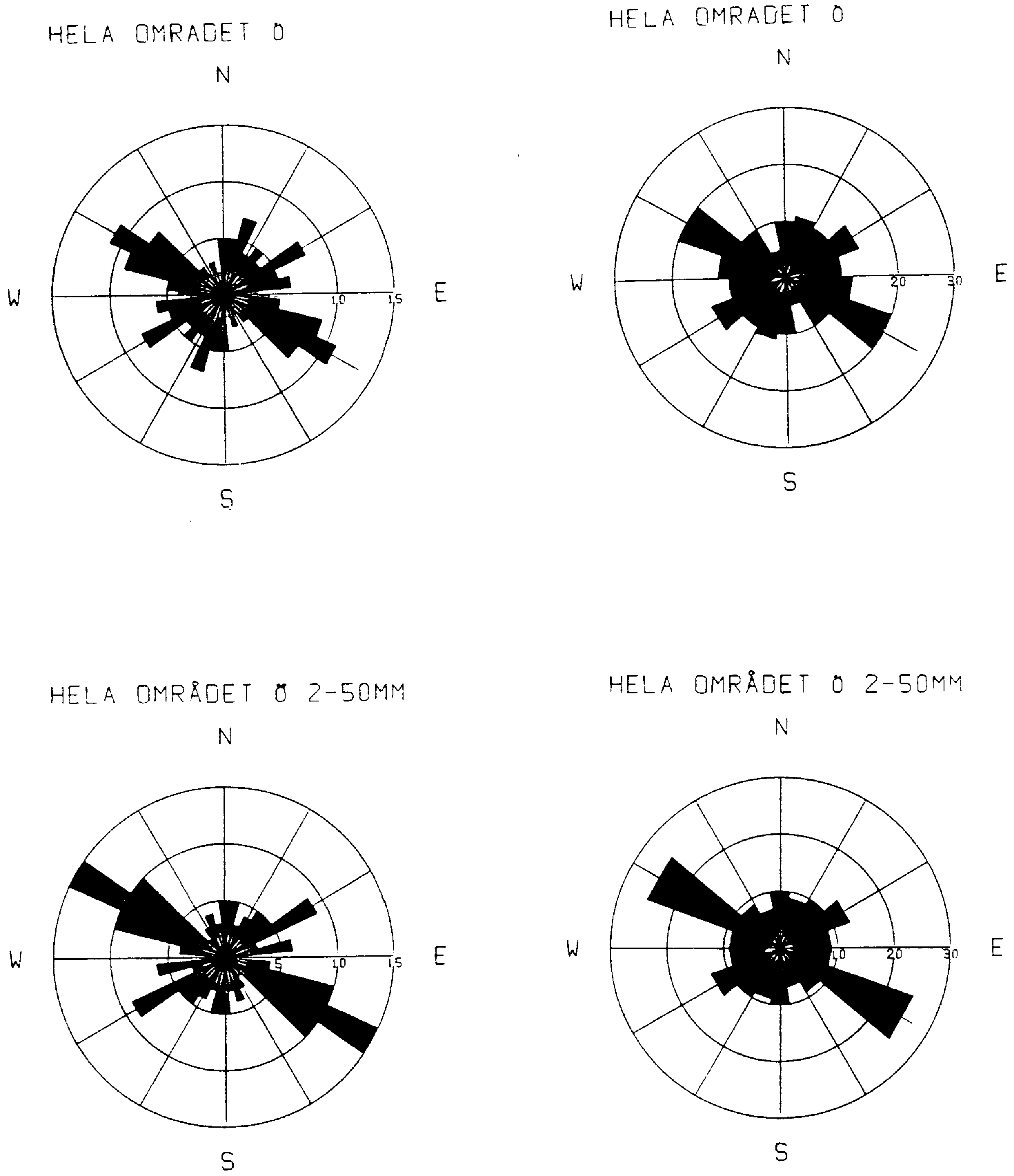



Figure 2.5  Example of generated rosette diagrams

## 2.3 EVALUATION OF SURFACE FRACTURE DATA

Processed surface fracture information has been used during the initial characterization of rock qualities of study site areas within the SKB study site program (eg Ahlbom et al 1980, Tire´n et al 1981).

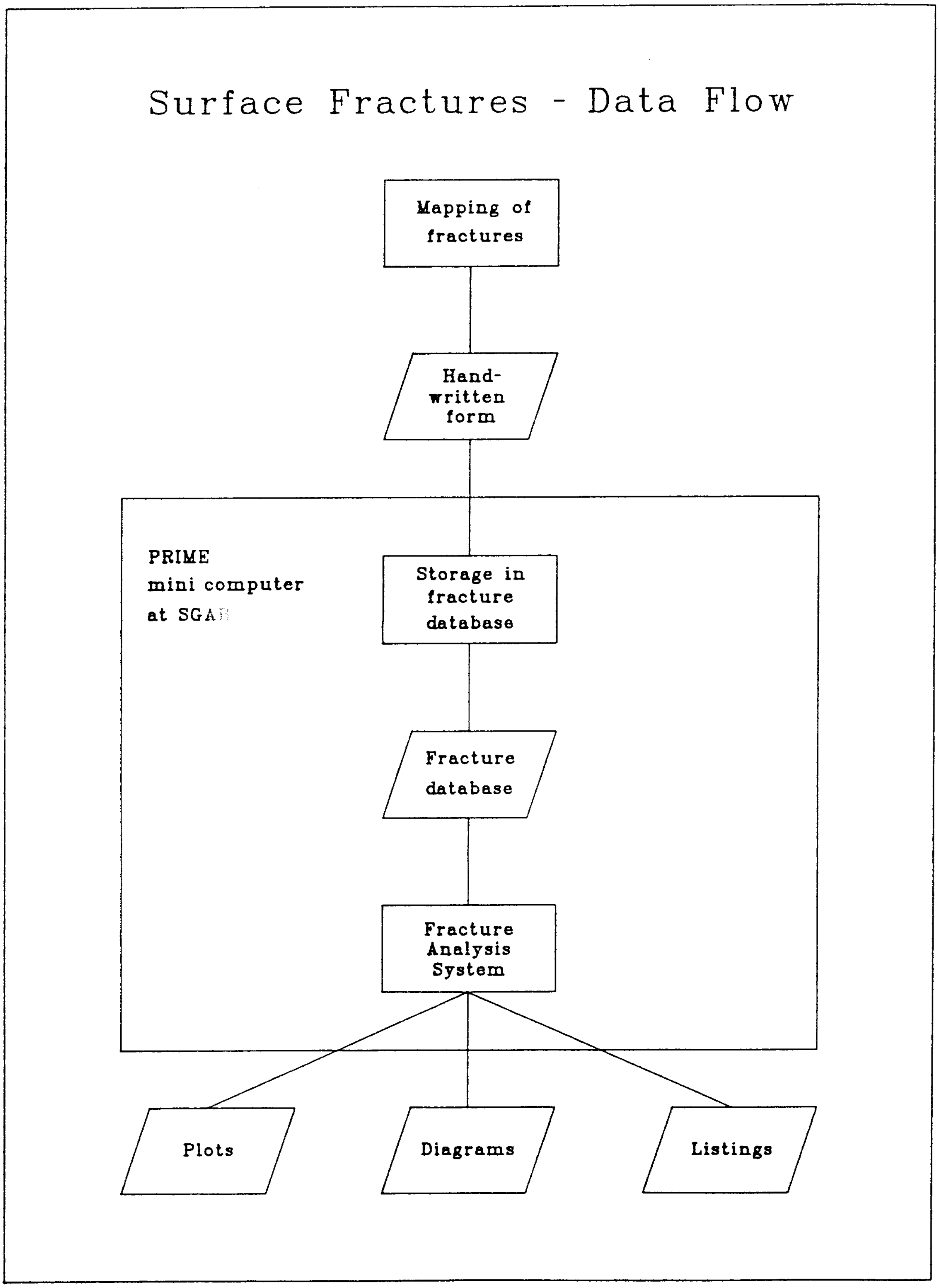



Figure 2.4. Surface Fractures - Data Flow

## 2.4 SURFACE FRACTURE DATA IN GEOTAB

Surface fracture data are stored in the following GEOTAB tables:

### Flyleaf and background information

| | |
|---|---|
| SFRACTF1 | Area information; date, mapping crew, responsible person, references |
| SFRACTF2 | Comments |
| SFRACTF3 | Measuring crosses; orientation and length |
| ACROSS | Measuring crosses; RAK X and Y coordinates |

### Data

| | |
|---|---|
| SFRD | Rock type |
| SFRDD | Fractures; profile, orientation, dip, type, width, length, characteristics |
| SFRND | Fractures; number of fractures, length, characteristics |
| SFRSD | Structural data; orientation, dip, element |

### Lexicons

| | | |
|---|---|---|
| SFLE | Element codes lexicon | (see Appendix C-4) |
| FLR | Rock codes lexicon | (see Appendix C-2) |
| FLM | Mineral codes lexicon | (see Appendix C-1) |
| SFLF | Fracture codes lexicon | (see Appendix C-4) |
| SFLP | Profile codes lexicon | (see Appendix C-4) |

# 3 CORE MAPPING

Core mapping has been performed at the following study sites:

| | |
|---|---|
| - Finnsjön | 6 boreholes |
| - Gallejaur | 1 borehole |
| - Gideå | 13 boreholes |
| - Kamlunge | 16 boreholes |
| - Klipperås | 14 boreholes |
| - Lansjärv | 1 borehole |
| - Taavinunnanen | 1 borehole |
| - Äspö | 3 boreholes |
| - Ävrö | 1 borehole |

The impact has been on fracture mapping, with a detailed mapping of single fractures, fracture zones and crushed zones. The rock mapping has been limited to rock type and angle to core axis.

The core mapping data flow is described in Figure 3.1.

For a sampl compilation of core mapping data for the Klipperås study site see (Egerth 1986).

## 3.1 ACQUISITION OF CORE MAPPING DATA

### 3.1.1 History

Before 1982 core mapping was registered on forms. A handdrawn corelog was produced for presentation of the mapped information.

In the beginning of 1982 SKB decided to develop a microcomputer based Core Mapping System to:

- rationalise the core mapping process
- automaticallly generate plotted "core logs"
- provide for further data processing by more strict codification of data

### 3.1.2 Data acquisition on forms

Before autumn 1982, acquisition of core mapping data was done on paper forms (see Appendix B-1) and presented as hand-drawn "core logs" showing fractures, fracture zones, crushed zones, rock type, fracture angles, minerals etc (see Appendix B-2).

### 3.1.3 Data acquisition with the Core Mapping System

The Core Mapping System was developed by SGAB, and implemented on an ABC800 microcomputer with dual 5 1/4" floppy disk drives and an attached Epson MX-100 matrix printer. The software was written in ABC BASIC and built around a commercial database system called "Basregister 800 Version 1.4". The main functions of the Core Mapping System are:

- Fracture mapping
- Rock type mapping
- Plotting of "core log"
- Calculation of fracture frequencies
- Plotting of fracture frequencies
- Listing of rock zones
- Listing/editing of database records
- Miscellaneous data administrative functions, such as floppy disk formatting, backup routine etc

Version 1 of the system was used from autumn 1982. During 1985 Version 2 of the system was developed. Version 1 is completely in Swedish, whereas Version 2 is completely in English. In Version 2 some improvements were made, for example a more detailed mapping of fracture zones. The following chapters will describe Version 1 of the system, since nearly all investigated areas up to the date of this report are mapped with Version 1.

See (Stark 1983) for a user description of the Core Mapping System.

### 3.1.3.1 Fracture and rock type mapping

The following list comprises the main menu of the fracture and rock type mapping routine in the system:

1 - Fractures, coated
2 - Fracture zone
3 - Crushed zone
4 - Sealed fracture
5 - Fresh fracture
6 - Uptake
7 - Rock type
8 - Core loss
9 - Notes

The user enters a depth (rounded to nearest 5 cm), and then selects the choice from the main menu, consistent with the core observation. Some menu choices have sub-menus, some do not. All choices will be explained in the chapters below. All menu texts have been translated into english in this report, though they are in Swedish in the Core Mapping System Version 1.

#### 3.1.3.1.1 Fractures, coated

The coated fractures menu has the following contents:

```
Number of fractures (1-99):
        Angles from (0-90):
                 to (0-90):
  Parallel foliation (Y/N):
                Mineral 1:
                Mineral 2:
                Mineral 3:
                Mineral 4:
                Mineral 5:
   Surface (V,S,O,P,L,M,Ö):
```

The surface character codes have the following meanings:

| Swedish code | | English code |
|---|---|---|
| V | Weathered | W |
| S | Smooth | S |
| O | Rough | R |
| P | Polished | P |
| L | Slickenside | L |
| M | Coated | C |
| Ö | Other | X |

Table 3.1. Surface character codes

In Version 2 the surface character codes were translated to english equivalents (see Table 3.1). These english equivalents are also used consistently in the GEOTAB database, even if data acquisition was originally performed with Version 1 of the Core Mapping System.

Mineral codes used conform to the code dictionary defined by the Swedish Geological Survey (see Appendix C-1).

3.1.3.1.2 Fracture zone

Begins or Stops (B/S):
Coated or Fresh (C/F):
Number of parallel (0-99):
Angles from (0-99):
to (0-99):
Number of crossing (0-99):
Angles from (0-90):
to (0-90):
Parallel foliation (Y/N):
Mineral 1:
Mineral 2:
Mineral 3:
Mineral 4:
Mineral 5:
Surface (V,S,O,P,L,M,Ö):

### 3.1.3.1.3 Crushed zone

Begins or Stops (B/S):
Mineral 1:
Mineral 2:
Mineral 3:
Mineral 4:
Mineral 5:
Surface (V,S,O,P,L,M,Ö):

### 3.1.3.1.4 Sealed fracture

This choice has no sub-menu. The given depth will be marked to contain a sealed fracture.

### 3.1.3.1.5 Fresh fracture

This choice has no sub-menu. The given depth will be marked to contain a fresh fracture.

### 3.1.3.1.6 Uptake

This choice has no sub-menu. The given depth will be marked to contain a core uptake.

### 3.1.3.1.7 Rock type

Rock code:
Prefix code:
Angle:

Rock and prefix codes used conform to the code dictionary defined by the Swedish Geological Survey (see Appendix C-2 and C-3). The parameter "Angle" is the angle to the core axis in degrees.

### 3.1.3.1.8 Core loss

Begins or Stops (B/S):

The given begin and stop depths will be marked as core loss borders.

3.1.3.1.9 Notes

Note (max 20 chars):
Should the note be printed on the core log plot (Y/N):

Notes are maximised to 20 characters and may optionally be printed at the core log plot.

3.1.3.2 Plotting of core log

A core log plot may be produced with the system, comprising all information stored for the complete borehole core (see Appendix B-3). A description of the plot layout is also produced by the system (see Appendix B-4).

3.1.3.3 Calculation of fracture frequencies

A routine for calculation of fracture frequency is included in the system. This routine will be described in the "Data processing" chapter.

3.1.3.4 Plotting of fracture frequency

The calculated fracture frequencies may be plotted on an attached HP7475A pen plotter. This routine will be described in the "Data processing" chapter.

3.1.3.5 Listing of rock zones

A printout of rock sections may be generated with the system. This routine will be described in the "Data processing" chapter.

3.1.3.6 Listing/editing of database records

With the database system routines in "Basregister 800", all data records stored with the Core Mapping System may be listed and edited. Also searching for specific data may be performed, but is seldom used in practice since it is more convenient to incorporate frequent searches in specific application programs and routines (like for instance fracture frequency calculation). In general, there is also seldom much use for the editing facilities, since the Core Mapping procedure has built in data checking for inconsistencies and errors.

#### 3.1.3.7 Miscellaneous data administrative functions

Included in the system are also routines for floppy disk formatting, backup of floppy disks and "Basregister 800" routines for "reparing" of databases that has been damaged due to floppy disk failures. Also included in the "Basregister 800" package, are routines for sorting database registers and for mathematical operations on database registers.

## 3.2 PROCESSING OF CORE MAPPING DATA

### 3.2.1 Fracture frequency

#### 3.2.1.1 Calculation

A fracture frequency calculation routine is included in the Core Mapping System. The fracture frequency for coated fractures may be calculated, where selection conditions for minerals and/or angle to core interval, may be set by the user.

For example, the fracture frequency for all fractures coated with the mineral calcite and with an angle to core between 30 and 60 degrees may be calculated. The section length may be chosen by the user, but is usually set to 1 meter.

Since the fractures in a fracture zone are collectively registered, the fracture frequency calculation routine will "spread" the number of fractures in the zone at equal distances, and if angle selection conditions are set, the number of fractures in the registered angle interval at equal distances.

Example:
A fracture zone between depths 53.00 m and 54.70 m is registered to contain 8 fractures in the angle interval 30-45 degrees. These 8 fractures will be placed at equal distances in the angle interval (30, 32.14, 34.29, 36.43, 38.57, 40.71, 42.86 and 45

degrees). If an angle selection condition is set to the angle interval 40-60 degrees, only 3 of the 8 fractures will be included in the fracture frequency calculation (40.71, 42.86 and 45 degrees). These 3 fractures will be spread at equal distances in the depth interval 53.00-54.70 m (53.00, 53.85 and 54.70 m).

Crushed zones will have a pre-defined fracture frequency of 50 fractures per meter.

#### 3.2.1.2 Plotting

A plot showing the fracture frequency along the borehole may be generated at an attached HP7475A plotter (see Appendix B-5). In the plot, the occurences of crushed zones and fracture zones in each section are marked.

### 3.2.2 Listing of rock codes

A list of the mapped rock zones with from-to depths and rock code, may be generated on the attached printer and/or on a disk file (see Appendix B-6).

## 3.3 EVALUATION OF CORE MAPPING DATA

Core mapping data have been used to evaluate:

- the distribution of different rock types
- the location of fracture zones in the bedrock and their orientation
- the distribution of different minerals in the fracture zones and solid rock
- correlations to geophysical loggings
- alteration of fracture zones
- ground water flow
- water chemistry

By using computer based core mapping it has been possible to evaluate core mapping data in a more objective and systematic way, compared to solely manual methods.

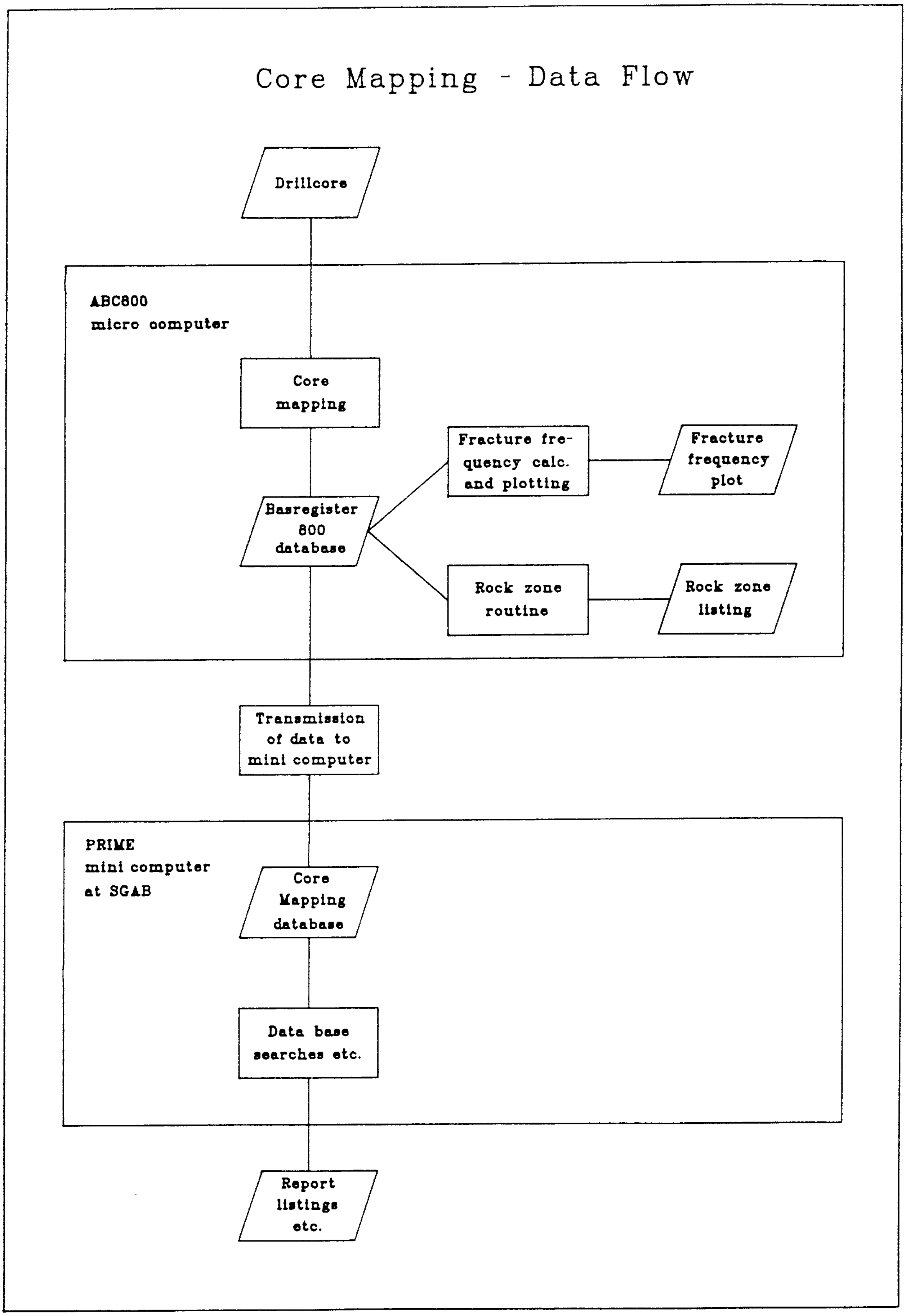



Figure 3.1 Core Mapping - Data Flow

## 3.4 CORE MAPPING DATA IN GEOTAB

Core mapping data are stored in the following GEOTAB tables:

### Flyleaf information

| | |
|---|---|
| CFRACTF1 | Borehole information; date, mapping crew, responsible person, references |
| CFRACTF2 | Borehole comments |
| CFRACTF3 | Core mapping comments |

### Data

| | |
|---|---|
| FRACTURE | Fractures; depth, angle interval, type, number of fractures |
| PARAFOL | Parallel foliation; depth |
| CRUSHZ | Crushed zones; depth |
| CLOSS | Core losses; depth |
| UPTAKE | Uptakes; depth |
| MINERAL | Minerals; depth, mineral code |
| CHARACTE | Fracture surface character; depth, character code |
| ROCK | Rock types; depth, prefix code, rock code, angle to core axis |

### Lexicons

| | |
|---|---|
| CMLFT | Fracture type lexicon (see Appendix C-5) |
| CMLC | Fracture surface character lexicon (see Appendix C-5) |
| CMLPC | Prefix code lexicon (see Appendix C-3) |
| FLR | Rock code lexicon (see Appendix C-2) |
| FLM | Mineral code lexicon (see Appendix C-1) |

# 4 CHEMICAL ANALYSES

Analyses of rock and core samples have been performed to a minor extent within the SKB study site program. Analyses have been performed on samples from the Fjällveden, Gideå, Kamlunge, Klipperås, Svartboberget and Taavinunnanen study sites.

The chemical analyses data flow is described in Figure 4.1.

Petrophysical analyses of rock and core samples are described in the report "Description of geophysical data in SKB´s database GEOTAB", which is being written parallel to this report.

## 4.1 ACQUISITION OF CHEMICAL ANALYSES DATA

Rock and core samples collected at the study sites have been sent to the laboratory at the Swedish Geological Co in Luleå, to be analyzed. Several different sample preparation, sample treatment and analyzing methods have been used, including:

Sample preparation

- Grinding in steel mill
- Grinding in tungsten carbide mill
- Grinding with additive in steel mill
- Grinding with additive in tungsten carbide mill

Sample treatment

- Grinding isoformation
- Dissolution after melting
- Total dissolution
- Total dissolution (HF, H2SO4)
- Acid leaching (HNO3, HCL)
- Gas generation
- Melting

Analyzing method

- Atomic absorption
- Atomic absorption (flame emission)
- X-ray fluorescence analysis
- Jumbo spectrophotometry
- Spectrophotometry
- Spectrometry (colorimetry)
- Electrochemistry
- Gravimetry
- Titrimetry

Analyses have been stored in a MIMER database on the PRIME mini computer at SGAB in Luleå.

## 4.2 PROCESSING OF CHEMICAL ANALYSES DATA

Chemical analyses data has not been further processed, only listed in reports etc.

## 4.3 EVALUATION OF CHEMICAL ANALYSES DATA

The analyses data has been used for rock classification where manual methods have been insufficient, or to chemically confirm manual interpretations.

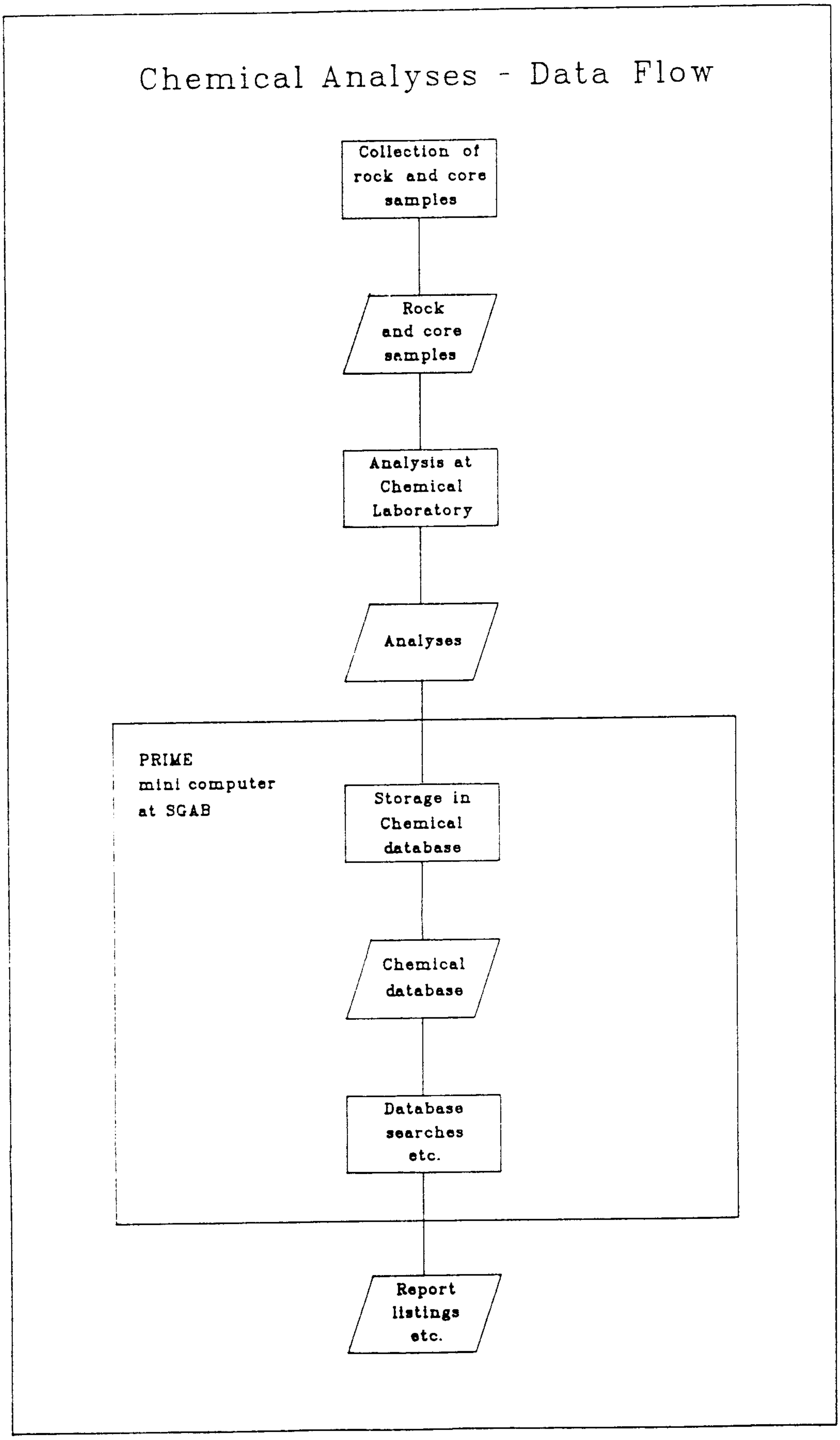



Figure 4.1 Chemical Analyses - Data Flow

## 4.4 CHEMICAL ANALYSES DATA IN GEOTAB

Chemical analyses data is stored in the following GEOTAB tables:

### Flyleaf information

| | |
|---|---|
| ARCHEMF | Area information; date, mapping crew, responsible person, references |
| BRCHEMF | Borehole information; date, mapping crew, responsible person, references |

### Data

| | |
|---|---|
| ARCHEMD1 | Rock sample analyses; trace elements |
| ARCHEMD2 | Rock sample analyses; main elements |
| ARCHEMD3 | Rock sample analyses; oxide elements |
| ARCHEMD4 | Rock sample analyses; remaining elements |
| BRCHEMD1 | Core sample analyses; trace elements |
| BRCHEMD2 | Core sample analyses; main elements |
| BRCHEMD3 | Core sample analyses; oxide elements |
| BRCHEMD4 | Core sample analyses; remaining elements |

### Lexicons

| | |
|---|---|
| RCLAM | Analyzing method code lexicon (see Appendix C-6) |
| RCLST | Sample treatment code lexicon (see Appendix C-6) |
| RCLSP | Sample preparation code lexicon (see Appendix C-6) |

## 5 ACKNOWLEDGEMENTS

The author wishes to thank Bengt Gentzschein, Göran Nilsson, Stefan Sehlstedt and Sven Tire´n for their help during the writing of this report.

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APPENDIX A-1

Surface fracture form - Area information

# HUVUDDATA

| PT (1) | GDA (3) | OMR NR (7) | TOP (12) | OMRÅDETS NAMN (17) | Y (33) | X (40–46) |
|---|---|---|---|---|---|---|
| 01 | BDAD | 0201 | 19JNV | GIDEÅ | 1664100 | 7045300 |
| ↓ | ↓ | 0202 | 19JNV | GIDEÅ | 1663250 | 7045750 |
| | | 0203 | 19JNV | GIDEÅ | 1663300 | 7045100 |
| | | 0204 | 19JNV | GIDEÅ | 1664000 | 7044500 |
| | | 0205 | 19JNV | GIDEÅ | 1664350 | 7045950 |
| | | 0206 | 19JNV | GULLMYRBERGET | 1664500 | 7043800 |
| | | 0207 | 19JNV | FAGERMYRBERGET | 1663000 | 7046750 |
| | | 0208 | 19JNV | SJÖBOTTBERGET | 1659300 | 7044300 |
| | | 0209 | 19JNV | FILLINGEN | 1672400 | 7041000 |
| | | 0210 | 19JNV | HÖVATTBERGET | 1661850 | 7040200 |

# MATKORSDATA

| PT | GDA | OMR NR | KORS NR | Y-KOORD | X-KOORD | PROFIL A ORIENT | PROFIL A LÄNGD | PROFIL B ORIENT | PROFIL B LÄNGD | BERGART |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 7 | 12 | 16 | 23 | 30 | 34 | 39 | 43 | 48 |
| 02 | BDAD | 201 | 1 | 1664095 | 7045320 | N37W | 15.0 | N60E | 9.5 | MHA |
| | | 201 | 2 | 1664005 | 7045265 | N78W | 13.0 | N25E | 11.5 | MHA |
| | | 201 | 3 | 1664130 | 7045265 | N08E | 14.0 | N52W | 10.0 | MHA |
| | | 201 | 4 | 1664135 | 7045305 | N90W | 20.3 | N06W | 10.0 | MHA |
| | | 201 | 5 | 1664155 | 7045370 | N42E | 24.5 | N33W | 12.0 | MHA |
| | | 202 | 1 | 1663335 | 7046630 | N22E | 15.0 | N62W | 10.0 | MHA |
| | | 202 | 2 | 1663225 | 7046825 | N50E | 27.0 | N34W | 13.6 | MHA |
| | | 202 | 3 | 1663180 | 7046895 | N80E | 23.5 | N20W | 10.5 | MHA |
| | | 202 | 4 | 1663215 | 7046705 | N60E | 17.8 | N32W | 10.2 | MHA |
| | | 202 | 5 | 1663240 | 7046635 | N26E | 18.0 | N65W | 11.0 | MHA |
| | | 203 | 1 | 1663330 | 7044935 | N68E | 16.1 | N22W | 9.6 | MHA |
| | | 203 | 2 | 1663355 | 7045050 | N28E | 18.6 | N62W | 12.5 | MHA |
| | | 203 | 3 | 1663320 | 7045105 | N45E | 15.5 | N52W | 15.8 | MHA |
| | | 203 | 4 | 1663280 | 7045185 | N70W | 19.5 | N82E | 10.0 | MHA, HSB |
| | | 203 | 5 | 1663240 | 7045195 | N76E | 27.0 | N27W | 22.7 | MHA |
| | | 204 | 1 | 1663785 | 7044570 | N28W | 12.7 | N58E | 20.0 | MHA |
| | | 204 | 2 | 1663720 | 7044410 | N10E | 17.4 | N85E | 8.5 | MHA, MHB |
| | | 204 | 3 | 1664015 | 7044670 | N62W | 18.2 | N45E | 24.6 | MHA |
| | | 204 | 4 | 1664060 | 7044615 | N12E | 40.7 | N80W | 14.8 | MHA |
| | | 204 | 5 | 1664200 | 7044525 | N04W | 23.2 | N88E | 13.2 | MHA |
| | | 205 | 1 | 1664395 | 7044800 | N[illegible]E | 16.7 | N15W | [illegible] | [illegible] |
| | | 205 | 2 | 1664340 | 7044860 | N85W | 13.4 | N08W | 11.5 | MHA |
| | | 205 | 3 | 1664390 | 7045010 | N14E | 17.4 | N85W | 16.2 | MHA |
| | | 205 | 4 | 1664335 | 7045060 | N12W | 16.6 | N72W | 13.5 | MHA |
| | | 205 | 5 | 1664290 | 7045075 | N46E | 32.9 | N45W | 9.5 | MHA |
| | | 206 | 1 | 1664500 | 7043920 | N14W | 13.9 | N78E | 9.6 | MHA |
| | | 206 | 2 | 1664460 | 7043800 | N12E | 46.4 | N78W | 14.0 | MHA |
| | | 206 | 3 | 1664500 | 7043800 | N10W | 32.0 | N80E | 12.0 | MHA |
| | | 206 | 4 | 1664480 | 7043680 | N62E | 21.4 | N0[illegible]W | 12.0 | MHA |
| | | 206 | 5 | 1664400 | 7043800 | N90E | 17.5 | N10E | 13.0 | MHA |
| | | 207 | 1 | 1663070 | 7046690 | N46W | 32.5 | N47E | 19.5 | MHA |

APPENDIX A-3

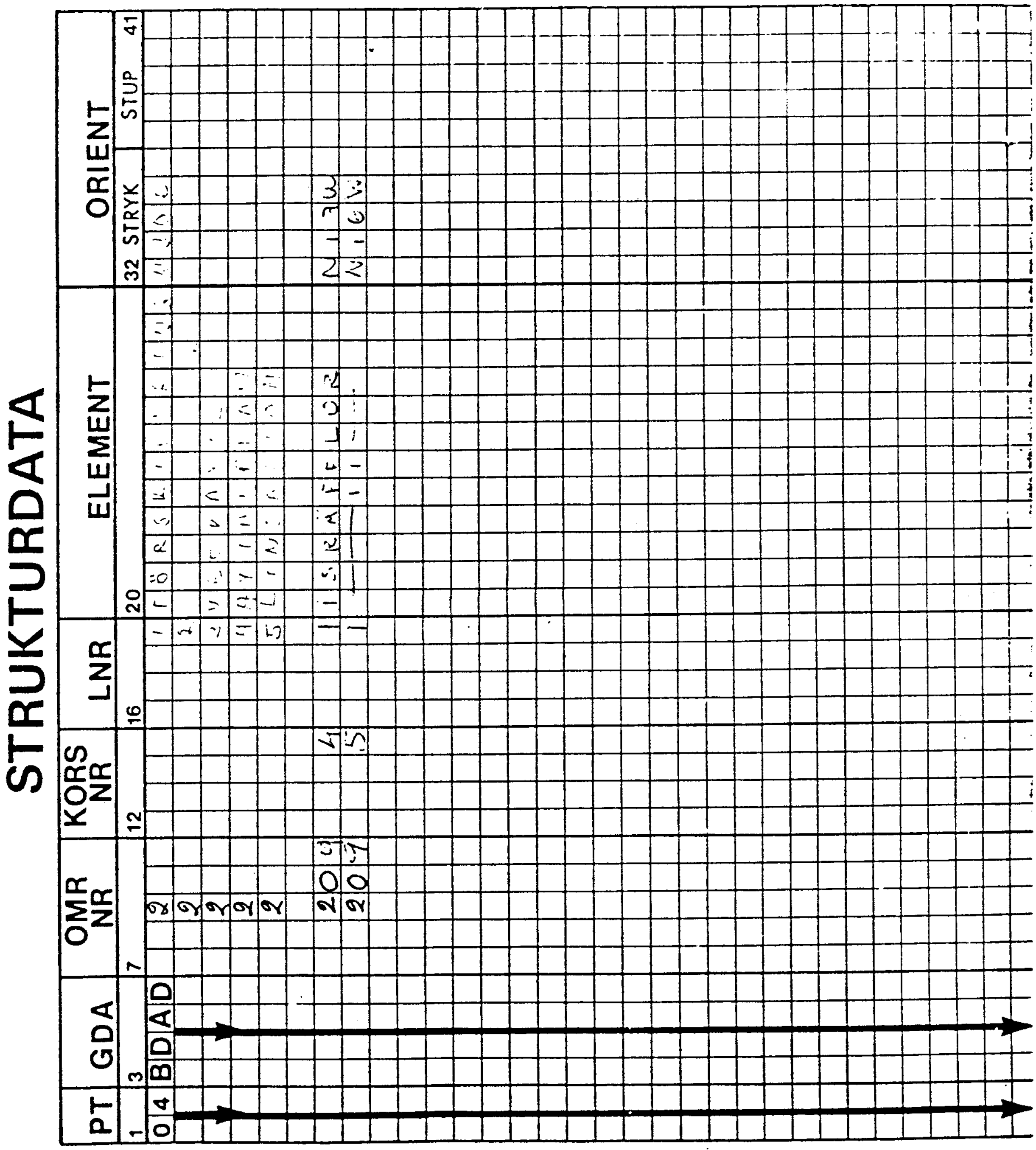
Surface fracture form - Fracture data

# SPRICKDATA

| PT (1) | GDA (3) | OMR NR (7) | KORS NR (12) | PROF (16) | NR (17) | STRY (21) | STUP (25) | ANT (29) | TYP (32) | BREDD (i mm) (35) | LÄNGD (i m) (39) | KARAKTÄR (43) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 03 | BDAD | 201 | 1 | A | 1 | N26E | 80S | 1 | Ö | 1 | 0 | |
| | | | | | 2 | N69W | | 2 | L | 1 | 1.5 | QZ |
| | | | | | 3 | N73W | | 1 | L | 1 | 1.0 | QZ |
| | | | | | 4 | N68W | 70S | 1 | S | 0 | 0 | |
| | | | | | 5 | N56W | 40S | 1 | Ö | 2 | 0 | |
| | | | | | 6 | N54E | 90 | 1 | L | 1 | 0 | |
| | | | | | 7 | N20E | | 1 | S | 1 | 0 | |
| | | | | | 8 | N56E | 80N | 1 | L | 5 | 0 | QZ, FSP |
| | | | | | 9 | EW | 70N | 1 | Ö | 2 | 0 | |
| | | | | | 10 | N10E | 90 | 1 | S-Ö | 0 | 0 | |
| | | | | | 11 | N22E | 90 | 1 | S-Ö | 0 | 0 | |
| | | | | | 12 | N35E | 70S | 1 | Ö | 4 | 0 | |
| | | | | | 13 | EW | 85N | 1 | S-Ö | 0 | 2.0 | |
| | | | | | 14 | N55E | 85S | 2 | S-Ö | 0 | 0 | |
| | | | | | 15 | N45E | | 1 | S | 0 | 1.0 | |
| | | | | | 16 | N38E | 20N | 1 | Ö | 2 | 0 | |
| | | | | | 17 | N67E | 85S | 1 | S-Ö | 0 | 1.5 | |
| | | | | | 18 | N70E | 60S | 1 | Ö | 4 | 0 | |
| | | | | | 19 | N62W | 80N | 1 | L | 1 | 1.5 | |
| | | | | | 20 | N52E | 90 | 2 | S | 0 | 1.0 | |
| | | | | | 21 | N72E | 85S | 1 | S-Ö | 0 | 0.7 | |
| | | | | | 22 | N58E | 80N | 2 | S-Ö | 0 | 0.5 | |
| | | | | | 23 | N70E | 75S | 1 | S-Ö | 0 | 0.5 | |
| | | | | | 24 | N32E | | 1 | L | 1 | 0 | QZ - FSP |
| | | | | | 25 | N32E | 90 | 1 | Ö | 3 | 0 | |
| | | | | | 26 | N32E | 70S | 1 | S-Ö | 0 | 0 | |
| | | | | | 27 | N76W | 85N | 1 | S-Ö | 0 | 1.2 | |
| | | | | | 28 | N76W | 90 | 1 | Ö | 1 | 0 | |
| | | | | | 29 | N85W | 90 | 1 | Ö | 3 | 0 | |
| | | | | | 30 | N27E | 90 | 1 | HLL | 0 | 0 | |
| | | 201 | 1 | B | 1 | N40W | 60S | 1 | Ö | 1 | 0 | |
| | | | | | 2 | N75W | 90 | 1 | S | 0 | 0 | |

APPENDIX A-4

Surface fracture form - Structural data



# STRUKTURDATA

| PT | GDA | OMR NR | KORS NR | LNR | ELEMENT | ORIENT STRYK | ORIENT STUP |
|---|---|---|---|---|---|---|---|
| 1 | 3 | 7 | 12 | 16 | 20 | 32 | 41 |
| 04 | BDAD | 2 | | 1 | FÖRSK[illegible] | [illegible] | |
| | | 2 | | 2 | | | |
| | | 2 | | 3 | [illegible] | | |
| | | 2 | | 4 | [illegible] | | |
| | | 2 | | 5 | [illegible] | | |
| | | 20[illegible] | 4 | 1 | ISRÄFFLOR | N17W | |
| | | 207 | 5 | 1 | [illegible] | N16W | |

APPENDIX A-5

Surface fracture form - Comments

## ANM - DATA

| PT | GDA | OMR NR | KORS NR | LNR | TEXT |
|---|---|---|---|---|---|
| 1 | 3 | 7 | 12 | 16 | 19 … 56 |
| 0 5 | B D A D | | | | |

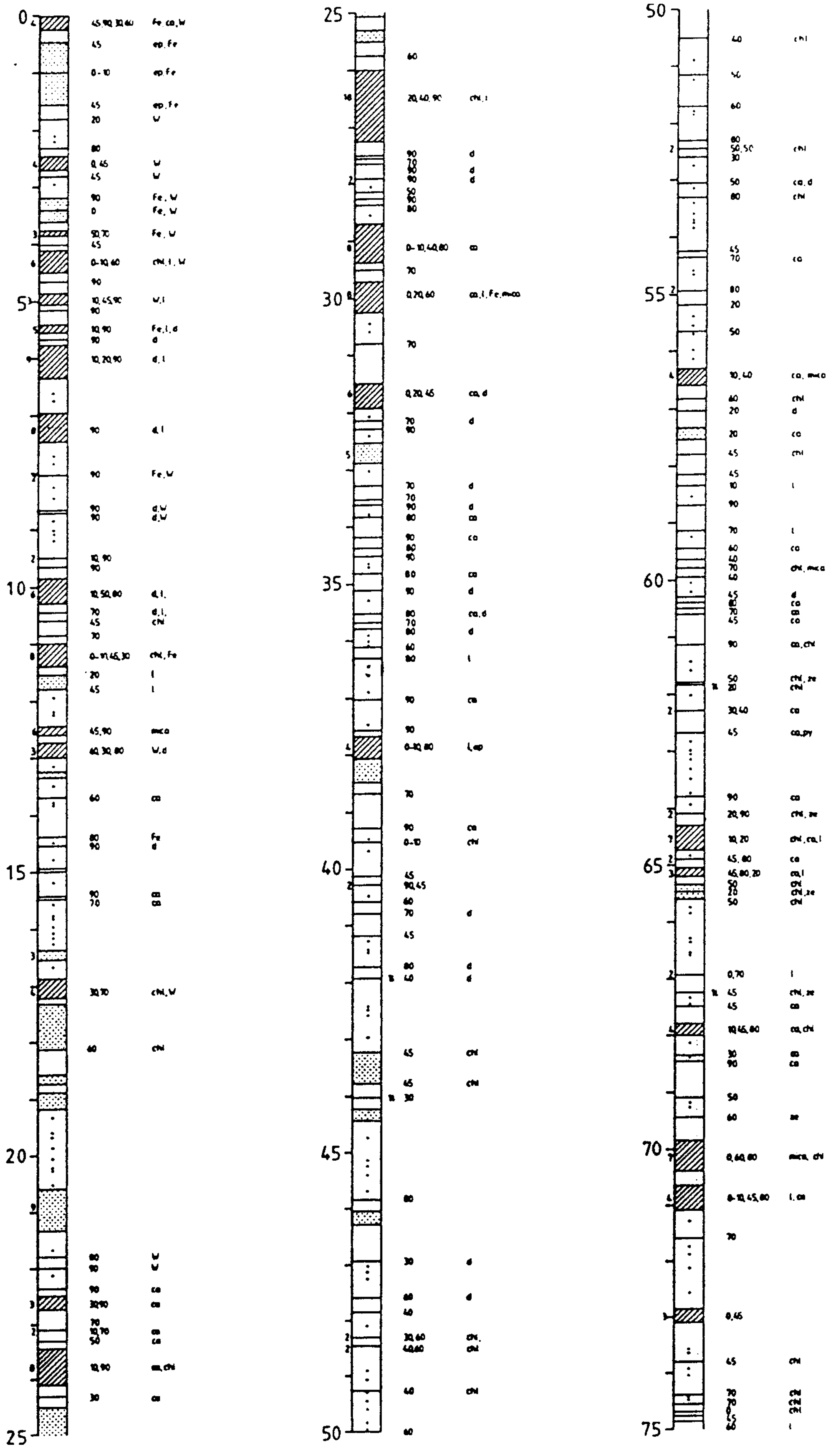
Core mapping form

**Fracture logging diagram**

| Depth (m) Uptake, U | Fracture type: individual (>10 cm dist.) Break: coated | fresh | No break: sealed | partly sealed | fracture indication | systems (< 10 cm dist.) fracture zone (f.z.) = f.z. with fresh surfaces f.z. with fresh and coated surfaces crushed zone gouge | number parallel crossing | Fracture character: coating: mineral thickness mm | weathered w smooth s rough r polished p partly polished p.p | angle to core axis | miscellaneous |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 00- 0,25 | X | | | | | f2 | 4 | Fe, ca | r w | 45,90,30,6 | |
| .45 - 1,55 | X | X | | | f2 | vertikal gående spricka mellan 0,45-1,30 | 3+14 | E, Fe | r r | 45 0-10,90 | U= 1,09 |
| 1.80 | X | | | | | | | m | r w | 20 | |
| 2.10 | | X | | | | | | | r | 90 | |
| U= 2.19 | | X | | | | | | | r | 70 | |
| 30 | X | | | | | | | m | r | 80 | |
| 2.45-.70 | X | X | | | | f2 | 4+2 | m | r w | 0,45,70 | |
| 80 | X | | | | | | | m | r w | 45 | |
| 95 | | X | | | | | | | r | 95 | |
| 3.20-.60 | X | X | | | | f2 borrkronsnära längs vertikalgående spricka | 2+6 | Fe | r w | 0,90 | |
| .75 - .86 | | | | | | f2 | 3 | Fe | r w | 50,70,90 | U= 3.86 |
| 4.00 | X | X | | | | | 1+1 | m | r | 45,90 | |
| .10 - .50 | X | | | | | f2 | 6 | chl, l | w | 0-10,60 | |
| 65 | X | | | | | | | m | r | 90 | |
| .85 - .05 | X | | | | | | | m, l | r w | 10,45 90 | |
| 5.15 | X | | | | | | | m | r | 90 | |
| .40 - .55 | X | | | | | f2 | 5 | Fe, l, d | r | 10,90 | |
| 5.65 | X | | | | | | | grönaktig lerlager | r | 90 | |
| .75 - 6.35 | X | ^ | | | | f2 | 9+1 | chl, l | r | 10,20,90 | U= 6.09 |
| .60 | | | X | | | | | | r | 90 | |

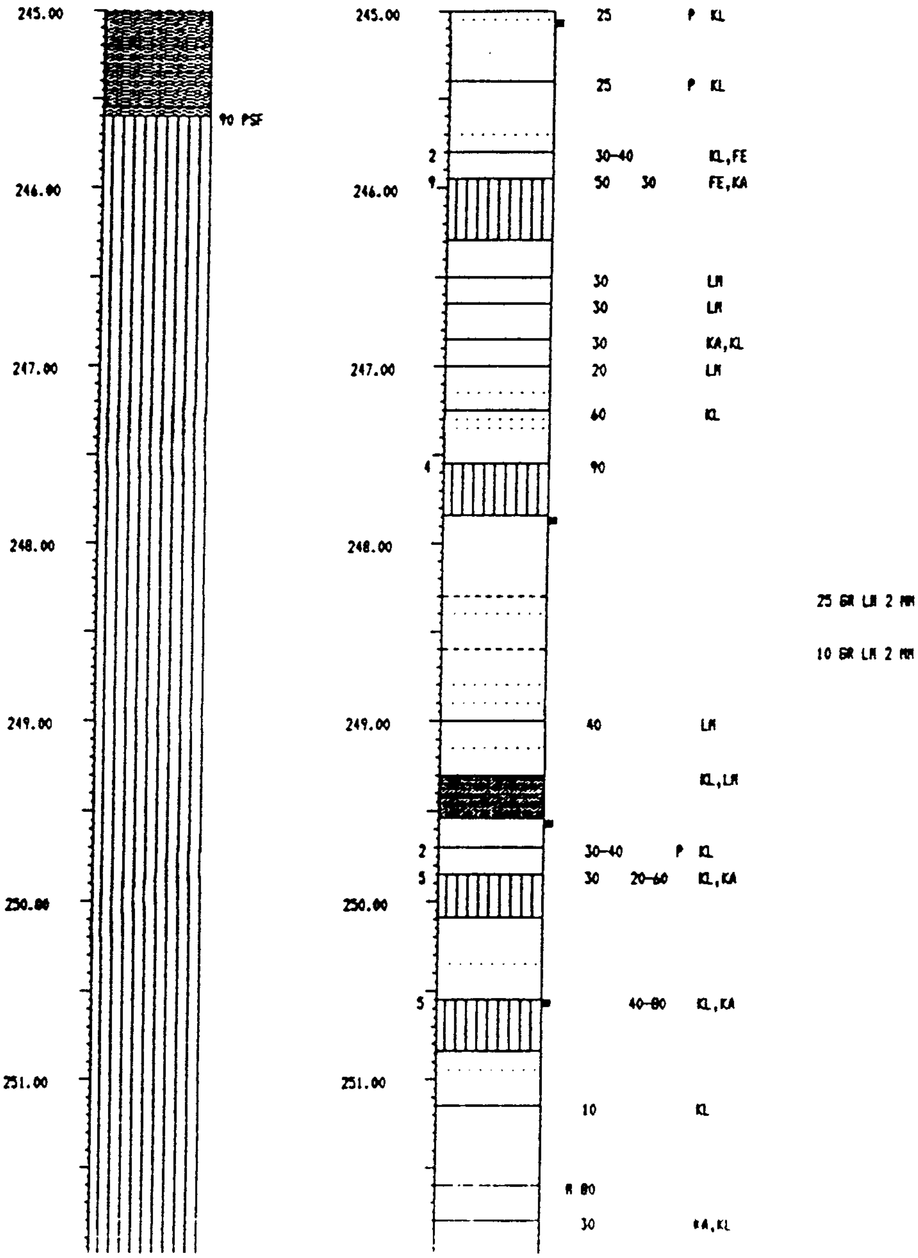
APPENDIX B-2

Hand drafted core log



APPENDIX B-3

Computer drafted core log

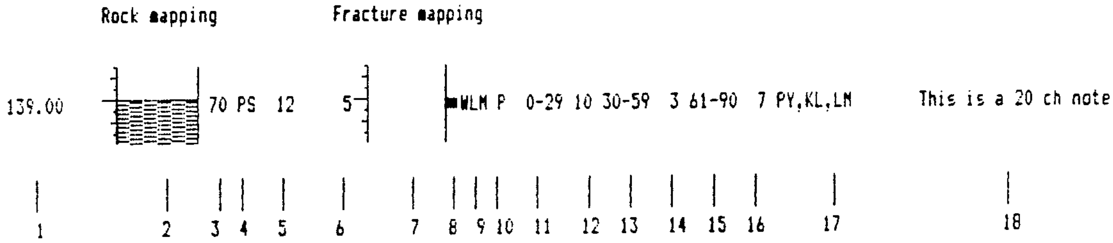


# APPENDIX B-4

## Plot description

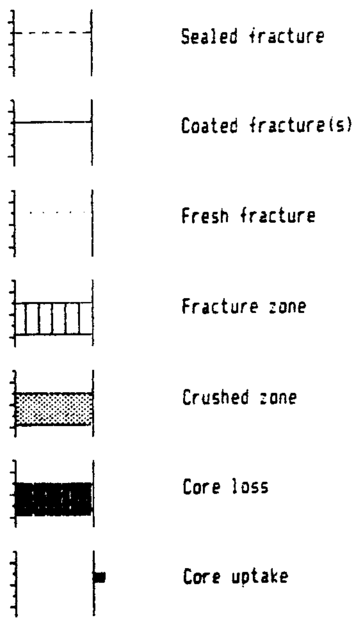
### Description

of plot symbols and codes



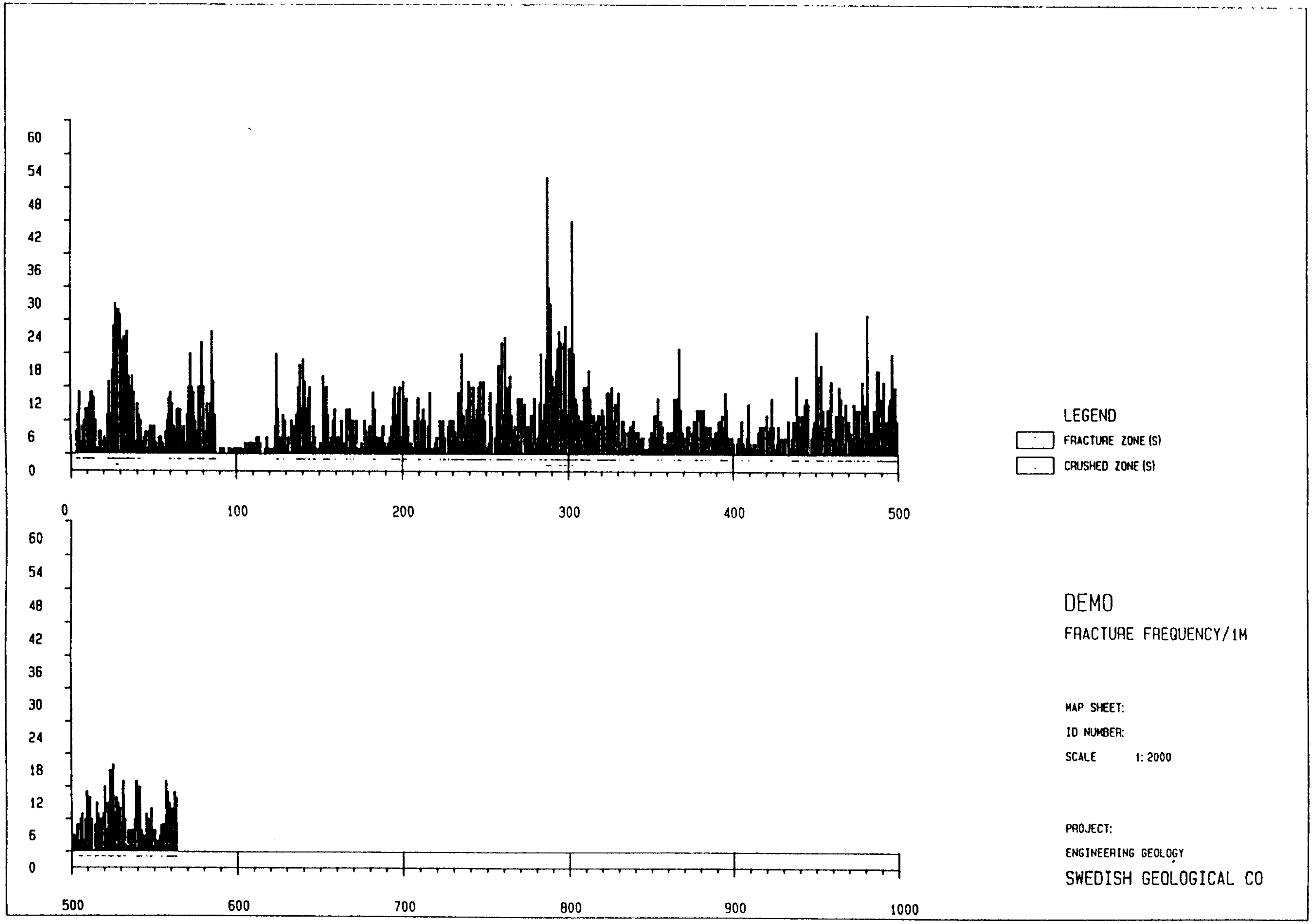

1 - Depth
2 - Rock classification
3 - Angle to core axis
4 - Code for rock type
5 - Prefix code for rock type
6 - Number of fractures
7 - Type of observation (see description below)
8 - Marking for core uptake
9 - Marking for weathered (V), slickenside (L) and coated (M) fractures
10 - Marking for parallel foliation
11 - Angle interval 1
12 - Number of fractures in interval 1
13 - Angle interval 2
14 - Number of fractures in interval 2
15 - Angle interval 3
16 - Number of fractures in interval 3
17 - Mineral codes
18 - Note

<u>Type of observation</u>



APPENDIX B-5

Fracture frequency plot



APPENDIX B-6

Listing of rock codes

Borehole

Rock zones

| From | To | Rock code |
|---|---|---|
| 3.70 | 71.15 | PSE |
| 71.15 | 71.95 | MMB |
| 71.95 | 75.10 | PSE |
| 75.10 | 79.80 | MMB |
| 79.80 | 85.00 | PSE |
| 85.00 | 86.40 | MMB |
| 86.40 | 140.60 | PSE |
| 140.60 | 143.90 | MMB |
| 143.90 | 153.40 | PSE |
| 153.40 | 155.80 | MMB |
| 155.80 | 167.35 | PSE |
| 167.35 | 169.25 | MMB |
| 169.25 | 170.20 | PSE |
| 170.20 | 187.00 | MMB |
| 187.00 | 192.70 | PSE |
| 192.70 | 193.65 | MMB |
| 193.65 | 218.15 | PSE |
| 218.15 | 219.85 | HSC |
| 219.85 | 223.00 | PSE |
| 223.00 | 223.65 | HSC |
| 223.65 | 228.90 | PSE |
| 228.90 | 229.05 | HSC |
| 229.05 | 234.05 | PSE |
| 234.05 | 236.10 | MMB |
| 236.10 | 236.65 | PSE |
| 236.65 | 236.75 | MMB |
| 236.75 | 249.10 | PSE |
| 249.10 | 250.10 | HSC |
| 250.10 | 283.85 | PSE |
| 283.85 | 289.00 | MMB |
| 289.00 | 308.00 | PSE |
| 308.00 | 309.15 | MMB |
| 309.15 | 316.40 | PSE |
| 316.40 | 317.90 | MMB |
| 317.90 | 318.75 | PSE |
| 318.75 | 325.25 | MMB |
| 325.25 | 343.25 | PSE |
| 343.25 | 344.60 | HSC |
| 344.60 | 345.60 | PSE |
| 345.60 | 345.85 | MMB |
| 345.85 | 390.90 | PSE |
| 390.90 | 391.25 | MMB |
| 391.25 | 409.10 | PSE |
| 409.10 | 409.80 | MMB |
| 409.80 | 421.20 | PSE |
| 421.20 | 421.75 | MMB |
| 421.75 | 443.95 | PSE |
| 443.95 | 444.60 | MMB |
| 444.60 | 449.90 | PSE |
| 449.90 | 460.00 | VS |
| 460.00 | 462.70 | PSE |
| 462.70 | 464.00 | MMB |
| 464.00 | 464.50 | PSE |
| 464.50 | 470.55 | MMB |
| 470.55 | 473.40 | VS |
| 473.40 | 473.70 | MMB |
| 473.70 | 478.00 | VS |

APPENDIX C-1 (1)

Mineral code dictionary

GEOTAB table FLM

| | |
|---|---|
| AD | Andalusite |
| AK | Arsenopyrite |
| AM | Amphibole |
| AP | Apatite |
| AZ | Azurite |
| BA | Baryte |
| BG | Galena |
| BI | Biotite |
| BR | Bornite |
| CM | Clay minerals |
| DI | Diopside |
| DL | Dolomite |
| EP | Epidote |
| FE | Iron oxide |
| FL | Fluorite |
| FM | Dark minerals |
| GA | Garnet |
| GL | Mica |
| GR | Graphite |
| HB | Hornblende |
| HM | Hematite |
| IL | Ilmenite |
| KA | Calcite |
| KB | Carbonate |
| KG | Cuprite |
| KK | Chalcopyrite |
| KL | Chlorite |
| KN | Caolinite |
| KR | Chromite |
| KS | Cassiterite |
| KY | Kyanite |
| LA | Laumontite |

APPENDIX C-1 (2)

LI Olivine
LM Light minerals
MA Malachite
MG Magnetite
MI Microcline
MK Pyrrhotite
ML Molybdenite
MT Magnesite
MU Muscovite
NE Nepheline
PE Pentlandite
PK Opaque minerals
PL Plagioclase
PR Prenhite
PT Pseudotachylyte
PX Pyroxene
PY Pyrite
QZ Quartz
RF Red feldspar
RU "Rust" minerals
SC Scheelite
SE Serpentine
SF Feldspars
SI Sillimanite
SK Scapolite
ST Sericite
SU Sulphides
TA Talc
TI Titanite
TR Tremolite
TU Tourmaline
UM Uranipherous mineral
VF White/grey feldspar
WL Wollastonite
WT Wolframite
ZB Sphalerite
ZE Zeolite
XX Unknown mineral

APPENDIX C-2 (1)

Rock code dictionary

GEOTAB table FLR

| | |
|---|---|
| BGT | Indeterminable rock |
| D | Various rocks |
| DB | Mafic rock |
| DBA | Basite (mafite) |
| DI | Intermediate rock |
| DS | Acid rock |
| DSA | Felsite |
| DSC | Ore quartzite |
| DSB | Leptite |
| DX | Volcanite and/or sediment |
| DY | Volcanite or plutonite |
| DZ | Xenolite |
| H | Hypabyssal rock |
| HB | Mafic hypabyssal rock |
| HBA | Porphyritic gabbro |
| HBB | Diabase |
| HBC | Olivine diabase |
| HBD | Lamprophyre |
| HF | Foidbearing hypabyssal rocks |
| HI | Intermediate hypabyssal rock |
| HIA | Porphyritic syenite |
| HIB | Porphyritic diorite |
| HS | Acid hypabyssal rock |
| HSA | Porphyritic granite |
| HSB | Pegmatite |
| HSC | Aplite |
| HSD | Granite-vein |
| HSE | Quartz-vein |
| HU | Ultra-mafic hypabyssal rock |
| HUA | Lamprophyre |
| HUB | Kimberlite |

APPENDIX C-2 (2)

M Metamorphic rock
MHB Veined gneiss
MHC High-grade metamorphic mica schist
MH High-grade metamorphic rock
MHA Migmattite MHG Glassy quartzite
MHE Charnochite
MHF Granulite
MHD High-grade metamorphic amphibolite
MHH Eclogite
MKB Hornfels
MKA Skarn
MKH Crystalline limestone
MK Contact metamorphic rock (tectite)
MLC Slate
MLD Low-grade metamorphic phyllite
ML Low-grade metamorphic rock
MLA Soapstone
MLB Greenschist
MMA Medium-grade metamorphic phyllite
MME Medium-grade metamorphic mica schist
MMF Graphite schist
MM Medium-grade metamorphic rock
MMG Quartzite
MMB Greenstone
MMD Medium-grade metamorphic amphibolite
MT Regional metamorphic rock (tectonites)
MTA Mylonite
MTB Tectonic breccia
MTC Tectonite
P Plutonite
PB Mafic plutonite
PBA Anorthosite
PBB Gabbro
PBC Leuco-gabbro

APPENDIX C-2 (3)

| | |
|---|---|
| PBD | Anorthositic gabbro |
| PBE | Gabbroic anorthosite |
| PBF | Mela-gabbro |
| PBG | Troctolite |
| PBH | Olivine gabbro |
| PBI | Gabbronorite |
| PBJ | Norite |
| PBK | Clinopyroxene norite |
| PBL | Orthopyroxene gabbro |
| PBM | Hornblende gabbro |
| PF | Foidbearing plutonites |
| PFA | Foidbearing alkali feldspar syenite |
| PFB | Foidbearing syenite |
| PFC | Foidbearing monzonite |
| PFD | Foidbearing monzodiorite |
| PFE | Foidbearing monzogabbro |
| PFF | Foidbearing diorite |
| PFG | Foidbearing gabbro |
| PFH | Foid syenite (nepheline syenite) |
| PFI | Foid monzosyenite (foid plagisyenite) |
| PFJ | Foid monzodiorite (essexite) |
| PFK | Foid monzogabbro |
| PFL | Foid diorite |
| PFM | Foid gabbro (theralite, teschenite) |
| PFN | Foidolite |
| PI | Intermediate plutonite |
| PIA | Alkali-feldspar syenite |
| PIB | Syenite |
| PIC | Monzonite |
| PID | Monzodiorite |
| PIE | Monzogabbro |
| PIF | Diorite |
| PS | Acid plutonite |
| PSA | Quartzolite |

APPENDIX C-2 (4)

| | |
|---|---|
| PSB | Quartzrich granitoids |
| PSC | Alkali-feldspar-granite |
| PSD | Alaskite |
| PSE | Granite |
| PSF | Granodiorite |
| PSG | Tonalite |
| PSH | Trondhjemite |
| PSI | Quartz-alkalifeldspar syenite |
| PSJ | Quartz syenite |
| PSK | Quartz monzonite |
| PSL | Quartz-monzo diorite |
| PSM | Quartz-monzo gabbro |
| PSN | Quartz diorite |
| PSO | Quartz gabbro |
| PSP | Quartz norite |
| PSR | Quartz anorthosite |
| PSS | Grey granodiorite |
| PST | Pink granodiorite |
| PSU | Red granodiorite |
| PSV | Red young granite |
| PU | Ultra-mafic plutonite |
| PUA | Peridotite |
| PUB | Dunite |
| PUC | Pyroxene peridotite |
| PUD | Harzburgite |
| PUE | Lherzolite |
| PUF | Wherlite |
| PUG | Pyroxene-hornblende peridotite |
| PUH | Hornblende peridotite |
| PUI | Pyroxenite |
| PUJ | Olivine pyroxenite |
| PUK | Olivine orthopyroxenite |
| PUL | Olivine websterite |
| PUM | Olivine clinopyroxenite |
| PUN | Olivine-hornblende-pyroxenite |
| PUO | Orthopyroxenite |
| PUP | Websterite |
| PUR | Clinopyroxenite |

APPENDIX C-2 (5)

PUS Hornblende pyroxenite

PUT Hornblendite

PUU Olivine hornblendite

PUV Olivine-pyroxene hornblendite

PUX Pyroxene hornblendite

PUY Perknite

PUZ Serpentinite

S Sedimentary rock

SA Sandstone (arenite)

SAA Quartz sandstone (quartz arenite)

SAB Arkose

SAC Lithic sandstone (subgreywacke)

SE Evaporite

SK Carbonaceous rock

SKA Limestone

SKB Calcareous sandstone

SKC Marl

SKD Dolomite

SKE Magnesite

SL Argillite

SLA Argillitic greywacke

SLB Siltstone

SLC Claystone (mudstone)

SLD Shale

SLE Alum shale

SN Nonclastic sediment

SNA Chert

SNB Flint

SNC Jaspilite

SND Quartz ore

SOI Soil

SR Conglomerate and breccia

SRA Orthoconglomerate

SRB Monogenetic conglomerate (oligomictic conglomerate)

APPENDIX C-2 (6)

SRC Polygenetic conglomerate (petromictic conglomerate)
SRD Paraconglomerate (diamictite)
SRE Tillite
SRF Sedimentary breccia
SW Wacke
SWA Quartzwacke
SWB Feldspathic greywacke
SWC Lithic greywacke
V Volcanite
VB Mafic volcanite
VBA Basalt
VBB Olivine basalt
VBT Tuffite
VF Foid volcanite
VFA Phonolite
VFB Tephritic phonolite
VFC Phonolitic tephrite
VFD Tephrite
VFE Phonolitic foidite
VFF Tephritic foidite
VFG Foidite
VFT Tuffite
VI Intermediate volcanite
VIA Intermediate lava: alkali trachyte
VIB Intermediate lava: trachyte
VIC Intermediate lava: latite
VID Intermediate lava: latite andesite
VIE Intermediate lava: latite basalt
VIF Intermediate lava: andesite
VIH Intermediate tuff: alkali trachyte
VII Intermediate tuff: trachyte
VIJ Intermediate tuff: latite
VIK Intermediate tuff: latite andesite
VIL Intermediate tuff: latite basalt

APPENDIX C-2 (7)

VIM Intermediate tuff: andesite

VIT Tuffite

VS Acid volcanite rock

VSA Acid lava: alkali rhyolite

VSB Acid lava: rhyolite

VSC Acid lava: rhyodacite (quartzlatite)

VSD Acid lava: dacite

VSE Acid lava: quartz andesite

VSH Acid tuff: alkali rhyolite

VSI Acid tuff: rhyolite

VSJ Acid tuff: rhyodacite (quartz latite)

VSK Acid tuff: dacite

VSL Acid tuff: quartz andesite

VST Tuffite

VU Ultra-mafic volcanite

VUA Picrite

XXX Ore

APPENDIX C-3

Prefix rock code dictionary

GEOTAB table CMLPC

| | |
|---|---|
| 11 | Pegmatite as veins and dykes |
| 12 | With undetermined fragments |
| 13 | With partly assimilated fragments |
| 14 | With inhomogenities |
| 15 | Altered to granite |
| 16 | Altered to sericite |
| 17 | Altered to chlorite |
| 18 | Altered to skarn |
| 19 | Altered to quartz |
| 20 | Altered to gneiss |
| 21 | Altered to veined gneiss |
| 22 | Hydrothermal alterations |
| 23 | Altered to albitite |
| 24 | Altered to scapolite |
| 25 | Altered to epidote |
| 26 | Altered to serpentine |
| 27 | Recrystalized |
| 28 | Tectonized |

APPENDIX C-4

GEOTAB table SFLE - Element codes lexicon

| | |
|---|---|
| AC | Axial plane foliation |
| AP | Axial plane |
| F | Fold axis |
| L | Lineation |
| S | Foliation |
| SL | Mineral lineation, rodding |

GEOTAB table SFLF - Fracture codes lexicon

| | |
|---|---|
| C | Closed |
| CO | Closed - open |
| CS | Closed - sealed |
| O | Open |
| OC | Open - closed |
| OS | Open - sealed |
| S | Sealed |
| SC | Sealed - closed |
| SO | Sealed - open |

GEOTAB table SFLP - Profile codes lexicon

| | |
|---|---|
| A | Profile A |
| B | Profile B |

APPENDIX C-5

GEOTAB table CMLFT - Fracture type codes lexicon

C Coated

F Fresh

S Sealed

GEOTAB table CMLC - Fracture surface character codes lexicon

C Coated

L Slickenside

P Polished

R Rough

S Smooth

W Weathered

X Other

APPENDIX C-6 (1)

GEOTAB table RCLAM - Analyzing method codes lexicon

A Atomic absorption
E Electrochemistry
F Spectrophotometry
G Gravimetry
J Jumbo spectrophotometry
K Gamma spectrometry
N Neutron activation
R X-ray fluorescence
S Spectrometry (colorimetry)
T Titrimetry
V Atomic absorption (flame emission)

GEOTAB table RCLST - Sample treatment codes lexicon

A Leaching with ascorbic acid - hydrogen peroxide
B Leaching with bromine water (HBr)
L Leaching with acid (HNO3, HCL)
M Grinding information
T Total dissolution
V Total dissolution (HF, H2SO4)
X Dissolution after melting

GEOTAB table RCLSP - Sample preparation codes lexicon

A Grinding in agate mill
G Grinding in jet mill
I Ashing
J Ashing with additive
S Grinding in steel mill
T grinding with additive in steel mill
V Mineral separation, till samples
W Grinding in tungsten carbide mill
X Grinding with additive in tungsten carbide mill

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[1]Chalmers University of Technology
[2]University of Linköping
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[1]Royal Institute of Technology, Stockholm, Sweden
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