

GEOTAB. Overview

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This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the author(s) and do not necessarily coincide with those of the client.

Information on SKB 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), 1987 (TR 87-33), 1988 (TR 88-32), 1989 (TR 89-40) and 1990 (TR 90-46) is available through SKB.

GEOTAB

Overview

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1. INTRODUCTION TO GEOTAB

Since 1977 Swedish Nuclear Fuel and Waste Management Co, SKB has been performing a research and development program for the final disposal of spent nuclear fuel. One aim of this program is to gain knowledge of different bedrock properties. Measurements for the characterization of geological, geophysical, hydrogeological and hydrochemical conditions are performed in specific site investigations as well as for geoscientific projects.

Large volumes of data have been produced since the start of the program, in the form of both raw data and results. During (the course of) the research program this data has been stored in various formats by different institutions and companies performing the investigations. It was therefore decided that all data from the research and development program should be stored in a single database.

The database, called Geotab, is a relational database, based on a database handling system from Mimer Information Systems. The application program, also called GEOTAB, was developed by Ergodata.

Overview

This manual provides a description of the basics of the database and application programs used in connection with GEOTAB. It is intended as a introduction for new and regular users.

The database is a mix of information organized so that storage, retrieval and modification of the data is as efficient as possible. GEOTAB is built around a relational database model. Data in a relational database is organized in tables, each table consists of horizontal rows and vertical columns.

	col.1	col.2	col.3	col.n
row 1				
row 2				

Figure 1.1 Structure of a table

Data In GEOTAB.

Each table in the database is completely self contained. However, to make retrieval easier, we have introduced a structure among the tables in GEOTAB.

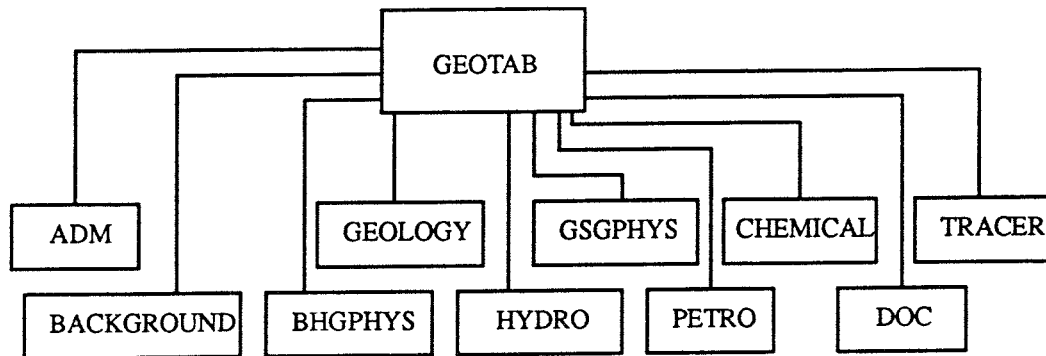


Figure 1.2 Structure of data in GEOTAB

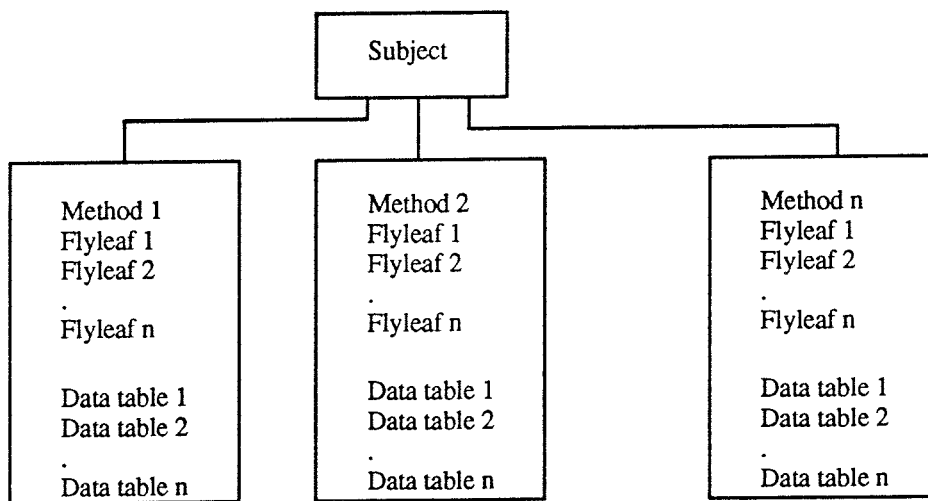


Figure 1.3 Structure of a subject

Subject: A group of methods forming a main subject from which data originates (hydrogeological, geophysical etc ...).

Method: Tables containing data from one type of measurement or calculation are grouped into methods.

Tables: There are two different kind of table types, flyleaf and data.

Manuals

Several manuals are available for GEOTAB in Directory GEODISK:<gd.sys.doc> on the SKB VAX system. The following manuals can be printed out from SKB VAX system:

- Operators Manual
This manual describes the general outlines, the everyday use and how to maintain and make changes in the Geodatabase system. It can be printed from file GEODISK:<GD.SYS.DOC>OPMAN.DOC
- System Manager Manual
This manual describe the tools provided for the Database Manager and a description of the structure of the geodatabase system. It can be printed from file GEODISK:<GD.SYS.DOC>SYSMAN.DOC
- System description
This manual describes program structure, files etc. used in GEOTAB. It can be printed from file GEODISK:<GD.SYS.DOC>SYSDESC.DOC
- Utilities manual
This manual describes standalone utilities, used in the Geodatabase system. It can be printed from file GEODISK:<GD.SYS.DOC>UTIL.DOC
- Introduction to GEOTAB
This manual is an introduction to GEOTAB and it can be printed from file GEODISK:<GD.SYS.DOC>INTRO.DOC

Other important documents are those technical reports that have been written to describe the different subjects and methods in GEOTAB.

The reports are:

- TR 86-22 Description of hydrogeological data in SKBs database GEOTAB.
- TR 88-05 Description of geophysical data in SKBs database GEOTAB.
- TR 88-06 Description of geological data in SKBs database GEOTAB.
- TR 89-02 Description of background data in SKBs database GEOTAB.
- TR 90-34 GEOTAB: Users Guide
- TR 91-01 Description of geological data in SKBs database GEOTAB, Versiion 2.
- TR 91-02 Description of geophysical data in SKBs database GEOTAB, Versiion 2.
- TR 91-05 Description of tracer data in SKBs database GEOTAB.
- TR 91-06 Description of background data in SKBs database GEOTAB, Version 2.
- TR 91-07 Description of hydrogeological data in SKBs database GEOTAB, Version 2.

To achieve a high degree of flexibility the database is divided into two logical parts, called system database or meta database and the stored data. The meta database is superior. It contains information on the organization of the database and the meta database. In other words it is self defining. This is useful when searching for a certain type of data. It also makes it simpler to make changes and add tables and data to the database.

2. ADM: ADMINISTRATIVE METHODS

SREPORT method include tables which are control tables in the status report system. The status report system consists of different programs with which several types of geotab status reports can be made. Each report type has its own identity. The report identities, the report layout and which information they will contain, are stored in tables (control tables).

All information that will be presented in a report, is collected from the control tables and COUNTTAB (GEOTAB data summary table).

Method Tables

Method	Tables
SREPORT	DVALS RAPPORT MOTTAGARLASTDATE VALCOLS PRESTYPE OBJGRUPP

Method with a short description are listed below:

- SREPORT: Status Report Method
 - * DVALS Contain domain values to mathed with COUNTTABs domain values
 - * RAPPORT Contains interval of time between generation of status report for the different report types
 - * MOTTAGAR Receiver for each report type
 - * LASTDATE Last date report was made for each report type
 - * VALCOLS Used to select rows from COUNTTAB
 - * PRESTYPE How to present values in report table matrix
 - * OBJGRUPP How to divide methods on object groups

3. BACKGROUND: BACKGROUND DATA

The Background data in the database provides information on the location of areas studied, borehole positions and also some drilling information.

The data is normally collected on forms or as notes and then stored into the database.

The background data group (subject), called Background, is divided into several subgroups (methods). Each method consists of one or several data tables.

Subject: Background

Method Tables

BGAREA	AREA	AREAFIXP	AREALIM	AREAREF
BGDRILL	DRILL			
BGDRILLP	DRILLPF	DRILLPD		
BGHOLE	BHNAME	BOREHOLE	CASEDIAM	CASETOP
	COREDIAM	HOLEDIAM	BHCOORD	BHHIST
BGTABLES	ROWTAB			
BGTOLR	TOLR			

Methods with a short description are listed below:

- BGAREA: Area Background Data
The BGAREA method provides information on areas where different types of investigations have been conducted or are still on-going. Results from these investigations are stored under other subjects in the database.
 - * AREA Area and area code connection
The table AREA contains the area name, the area code and also the name of the topographic map covering the area considered.
 - * AREAFIXP Area fixpoints
True RAK fixpoints or fixpoints measured from a RAK fixpoint are used to locate the origin of the grid net itself in the RAK system. These fixpoints are collected in AREAFIXP.
 - * AREALIM Grid corner
If the investigation of an area has reached the point where ground geophysical measurements will be taken, a grid net must be available. This table contains corner coordinates of the grid net. If the grid net is rectangular, four pairs of coordinates are needed to describe the net. The coordinates given are local coordinates.
 - * AREAREF Area reference points
The local grid net with reference points in the field degenerates rapidly. Most of the reference points disappears after a few years. To be able to restore the net for use in further investigations, a series of so called area reference points are used. Small metal plates with local coordinates are nailed to tree stumps left along the T-lines of the grid net. The local coordinates of these points are collected in AREAREF.
- BGDRILL: Drilling Information
General information from drilling events are collected in the method BGDRILL. The method consists only of one table.

- * DRILL Drilling information
The DRILL table contains information on the type of drill rig used and the drilling company. Drilling periods and the borehole length are also included.
- BGDRILLP: Drilling Penetration
The method BGDRILLP contains information concerning drill penetration during percussion drilling.
 - * DRILLPF Drilling information
The table contains information on drilling company, crew etc.
 - * DRILLPD Drill penetration data
The table contains drill penetration data.
- BGHOLE: Borehole Information
During the investigation of an area, a series of core and percussion boreholes are drilled. The method BGHOLE contains different types of information concerning the boreholes. The method consists of the following tables:
 - * BHNAME Connection between area code and borehole idcode.
This table describes the connection between borehole type, area code and borehole idcode. The table is used as a check table, to prevent data storage under an illegal idcode.
 - * BOREHOLE Borehole information
General borehole information is collected in this table. This includes the borehole code, local and RAK coordinates, altitude, borehole length and intended orientation.
 - * HOLEDIAM Borehole diameter
In this table, the diameter for a given section in a borehole is stored. Normally the diameter is constant along the entire borehole length, but it may vary in some boreholes.
 - * COREDIAM Borehole core diameter
This table contains information on drill core diameter.
 - * CASEDIAM Borehole casing diameter
To prevent borehole collapse in the soil layer, an iron casing pipe is inserted into the bedrock during the drilling. In general, only one diameter is used in a borehole, but in some cases several diameters are used. The table CASEDIAM gives the diameter of the casing pipe.
 - * CASETOP Casing above ground
This table contains information on casing length above a reference level. Since the casing pipe is used to attach different types of equipment, its length is sometimes reduced or increased. This information is interesting when measuring methods that later must be compared with each other are used.
 - * BHCOORD Coordinates along borehole
Table BHCOORD contains calculated local coordinates, vertical depths from the top of a casing and meters above sea level (MASL) for different lengths along the borehole. These values are generated and loaded into the table by a program, using information from the

table DEVANGLE (DECLIN and INCLIN) and the table AREA (DIRGRID and DEV). The program is run automatically every night.

- * BHHIST Events occurred in borehole
Events such as the loss of equipment in borehole, blocked borehole etc, can be recorded in this table. So far no data has been loaded into this table.

- BGTABLES: Number Of Rows In Table
This method was created to gather information concerning what data is present in the database. The method consists of one table only.
 - * ROWTAB
In this table, information on the number of rows (records) in each database table is found. This table must be updated manually and it is therefore seldom up to date.

- BGTOLR: Data Tolerance Background Table
The accuracy of the data depends on how each parameter was measured. The same type of measurement might be made with different instruments or the equipment might have been modified to give higher resolution. Nevertheless, all data in a specific table is stored in the same format. This might give a false picture of the accuracy or sensitivity of different measurements.

The method BGTOLR consists of only one table.

- * TOLR
The measuring sensitivity or accuracy for different data are stored in this table.

You will find more detailed information about the background data in the SKB report: TR89-02. Description of background data in the SKB database Geotab. SGAB. Ebbe Eriksson and Stefan Sehlstedt.
TR91-06. Description of background data in the SKB database Geotab, Version 2. SGAB. Ebbe Eriksson and Stefan Sehlstedt.

4. DOC: DOCUMENTATION AND REPORTS

The documentation of data in the database provides information on documentation and reports associated to geotab area.

The documentation data group (subject), called DOC, consists of one method.

Subject: DOC

Method Tables

REPORT REPTAB

Method with short description is listed below:

– REPORT – List of skb reports

* REPTAB

REPTAB describes the report number, report type, by what company it was written, report headline and author(s).

You will find more detailed information about documents in SKBs document retrieval system running on PC.

5. HYDRO: HYDROGEOLOGICAL DATA

The result of the hydrogeological investigations have been divided into 15 methods and each method is presented separately in the database.

Three of them comprise data that have been evaluated or calculated on the basis of the results from other methods. In this case they constitute hydraulic conductivity values at different depths for defined hydraulic units of the bedrock.

They are according to content:

Method	Tables				
CONDINT	CONDINF1	CONDINF2	CONDINTD		
GRWB	GRWBF1	GRWBF2	GRWBD	GRWBSD	
PIEZO	PIEZOF1	PIEZOF2	PIEZOF3	PIEZOF4	PIEZOF5
	PIEZOF6	PIEZOPD	PIEZOSPD	PIEZOSLD	PIEZOLD
HUFZ	HUFZF	HUFZCD			
HURM	HURMF	HURMCD			
HYCHEM	HYCHEMF1	HYCHEMF2	HYCHEMF3		
PUMPTEST	PUMPF1	PUMPF2	PUMPF3	PUMPF4	
	PUMPF5	PUMPGEOM	PUMPVD	PUMPQD	
	PUMPD	PUMPPSEC	PUMPLSEC	PUMPCD	
	RECTES	RECTESF1	RECTESF2	RECTESF3	RECTESQD
	RECTESVD	RECTESLD	RECTESCD		
ROCKRM	ROCKRMF	ROCKRMCD			
SFHEAD	SFHEADF1	SFHEADF2	SFHEADF3	SFHEADCD	
SHBUP	SHBUPF1	SHBUPF2	SHBUPD	SHBUPCD	
SHSINJ	SHSINJF1	SHSINJF2	SHSINJF3	SHSINJP	SHSINJD
	SHSINJCD				
SHTINJ	SHTINJF1	SHTINJF2	SHTINJF3	SHTINJF4	
	SHTINJF5	SHTINJD	SHTINJCD		
SHTOLD	SHTINJOD				
FLOWME	FLOWMEF1	FLOWMEF2	FLOWMEF3	FLOWCAL	
	FLOWMED	FLOWMECD	FLOWMELD		

Methods are listed below with a short description:

Physiochemical properties

- CONDINT: Electrical Conductivity in Pumped Water
Measurement of electrical conductivity of water pumped from an aquifer during an interference test.

Groundwater levels and head registrations.

- GRWB: Groundwater Level Measurements in Boreholes
The position of the groundwater head has been determined by measurements of the groundwater level in boreholes distributed over a specific area and for a certain time. The measurements have been carried out partly by manual level registrations utilizing sounding equipment, and partly by continuous monitoring equipment. The latter were water level gauges before 1984. Since 1984 the GRUND, BORRE and PIEZOMAC systems are in use. Some boreholes have been sectioned off with inflatable rubber packers and the groundwater head has been registered above and/or below the packers.

- **PIEZO: Piezometric Measurements With the Piezomac System**
The purpose of the piezometric measurements is to determine natural piezometric pressure variations at different depths in the bedrock. This is done by sealing of deep boreholes into measurement sections (1–5 sections in each borehole) using inflatable rubber packers and then monitoring the groundwater head of the individual sections.

Hydraulic conductivity.

HUFZ: Hydraulic Unit Fracture Zone

The bedrock in some of the investigated study sites has been subdivided into hydraulic units according to differences in geological, tectonic and hydraulic properties. The following three main groups have been identified:

- rock mass
- local fracture zones
- regional fracture zones

The hydraulic conductivity values of the borehole intervals that intersect the fracture zones are determined from the results of the transient injection tests (SHTINJ). In the database local fracture zones and regional fracture zones are brought together to one method called fracture zones.

- **HURM: Hydraulic Unit Rock Mass**
The bedrock in some of the investigated study sites has been subdivided into hydraulic units according to differences in geological, tectonic and hydraulic properties. The following three main groups have been identified:

- rock mass
- local fracture zones
- regional fracture zones

The hydraulic conductivity values of the measurement sections that do not intersect the fracture zones represent the hydraulic unit rock mass.

- **HYCHEM: Hydraulic Tests During Chemical Sampling**
During chemical sampling of borehole fluid a packer sealed section is pumped during one week and after that a recovery period of at least 7–8 hours.
Pressure is registered and medium flow since last measurements is calculated and after plotting different hydraulic parameters can be calculated.

- **PUMPTTEST: Interference Test**
The purpose of the interference tests so far has been to characterize the hydraulic properties of fracture zones for greater volumes of rock than those tested with single hole technique.
An interference test starts with a "pump phase", when water is pumped at constant flow capacity from or to a borehole. After a period, varying between some hours to some weeks, the pumping is stopped and a "recovery phase" starts. During the whole test period the variations of the groundwater levels or the groundwater pressure are registered in all the influenced boreholes and measurement sections.

- RECTES: Recovery Test
The purpose of the recovery test is to determine preliminary hydraulic data for the borehole in combination with drilling. The measurement are carried out partly in connection with water sampling continuous core drilling in sections delimited with packers and partly during and after drilling of percussion boreholes.
- ROCKRM: Hydraulic Unit Rock Types In The Rock Mass
The bedrock in some of the investigated study sites has been subdivided into hydraulic units according to differences in geological, tectonic and hydraulic properties. The following three main groups have been identified:
 - rock mass
 - local fracture zones
 - regional fracture zones

In some study sites, layers of subordinate rock types have higher hydraulic conductivity than the host rock. In these cases, the rock mass has been divided into sub units, each unit representing either the host rock or the subordinate rock

- SFHEAD: Falling Head Test
The falling-head method admits an almost simultaneous estimation of the hydraulic conductivity and piezometric head for a given test section. The method can be described as a water loss measurement with a varying and decreasing excess head as opposed to the pressure-head method (SHSINJ) which is carried out with a constant excess head.
- SHBUP: Build-Up Test
The water pressure in sealed off sections in boreholes from underground normally exceed the actual collar level. Due to this excess pressure and inward gradient, water will flow from an opened section through the borehole out into the excavation. During the build-up tests a valve to a selected section is opened and the flow of water out of the section is registered. The flow will stabilize after some time and a state of equilibrium between the pressure in the actual section and in the tunnel will be reached. After closing the section, the build-up phase begins with monitoring the pressure.
- SHSINJ: Single Hole Steady State Injection Test
The purpose of the steady state injection test is to determine the hydraulic conductivity of the bedrock as exposed in boreholes. The tests are performed in sections delimited with rubber packers.
- SHTINJ: Single Hole Transient Injection Test
The purpose of the single hole transient injection test is to determine the hydraulic conductivity and other hydraulic parameters of the bedrock such as skinfactor and piezometric pressure. During the test, water is injected down to test sections which are sealed off by inflatable rubber packers.
- SHTOLD: Single Hole Transient Injection Test – Old Calculate Data
A recalculation of single hole transient injection test data was carried out 1986 for all sites. The old calculations are saved in its own method SHTOLD.

Miscellaneous

-- FLOWME: Flowmeter Logging

Flowmeter surveys are used to indicate relative flow rate profile along boreholes. The measurement provide valuable information too; for the identification of major water bearing, conducting distribution (early data) sectioning borehole for piezometric pressure recording zones, locate zones where circulation of water during drilling was lost and finally to locate holes in casing or tubing.

You will find more detailed information about the geohydrological data in the SKB report: TR 86-22 Description of hydrogeological data in SKB's database GEOTAB. Bengt Gentschein.

TR 91-07 Description of hydrogeological data in SKB's database GEOTAB, Version 2. Editor Margareta Gerlach.

6. GEOLOGY: GEOLOGICAL DATA

The geological investigations is divided into several methods and each method is presented separately in the database. In addition there is one method containing lexicon data for the other methods.

The data in the subject GEOLOGY is divided into several methods, consisting of one or several flyleaf tables (F) and one or several data tables (D).

Subject: GEOLOGY

Method	Tables			
ARCHEM	ARCHEMF	ARCHEMD1	ARCHEMD2	ARCHEMD3
	ARCHEMD4			
BRCHEM	BRCHEMF	BRCHEMD1	BRCHEMD2	BRCHEMD3
	BRCHEMD4			
CFRACT	CFRACTF1	CFRACTF2	CFRACTF3	FRACTURE
	PARAFOL	CRUSHZ	CLOSS	UPTAKE
	MINERAL	CHARACTE	ROCK	
OFRAC	OFRACF1	OFRACF2	OFRACD	
PCFRACT	PCFRACF1	PCFRACF2	PCFRACF3	BREAK
	NJOINT	SJOINT	CRUSH	ROCKTYPE
	STRFEA	ALTER		
	COREREC	CORLOS	FILL	ROUGHN
	SURFACE	SKIN	VEIN	ENDORI
	RORIANG	ORIFRA		
SFRACT	SFRACTF1	SFRACTF2	SFRACTF3	SFRD
	SFRDD	SFRND	SFRSD	
GEOCHECK	GCHECKF	FLM	FLR	CMLC
	CMLFT	CMLPC	SFLE	SFLF
	SFLP	RCLAM	RCLSP	PCLBREAK
	PCLRCOL	PCLRSTR	PCLRINT	PCLRGRA
	PCLRTEX	PCLSTRUC	PCLSTRIN	PCLALTER
	PCLAINT	PCLRECOV	PCLEO	PCLOF
	PCLCL	PCLVAR	PCLROUGH	PCLSURF
	PCLSKIN			

Methods with a short description are listed below:

- ARCHEM: Area Rock Chemical Analyses
Analyses of surface rock samples have been performed to a minor extent within the SKB study site program. Rock 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 treatment and analyzing methods have been used.
- BRCHEM: Borehole Rock Chemical Analyses
Analyses of borehole rock samples have been performed to a minor extent within the SKB study site program. Rock 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 treatment and analyzing methods have been used.

- **CFRACT: Core Mapping Data**
Core mapping data has been collected with the ABC800 microcomputer based Core Mapping System developed by Swedish Geological Co. 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 system was used between 1982 and 1988.
- **PCFRACT: PetroCore Core Mapping Data**
Core mapping data has also been collected with the IBM-PC based PetroCore system developed by PetroBloc AB. A more detailed fracture and rock type mapping has been performed with this system than with the older (ABC 800) system. The system has been used since mid 1988.
- **SFRACT: Surface Fracture Data**
When studying the qualities of the bedrock at the SKB study sites, information about small fractures in outcrops have been systematically collected. The methodology used for representing fracture information is based on an orthogonal configuration of two sampling lines. The fracture number is represented as the frequency of intersections between the fractures and the sampling lines irrespectively of the orientation of the fractures.
- **GEOCHECK: Geological Check Tables (Lexicon)**
Lexicon for rock types, minerals, fracture types etc. The rock type and mineral lexicon is based on the lexicon used by the Geological Survey of Sweden.
- **OFRAC: Outcrop Fracture Data**
To study the relation between rock mechanics and hydrology around Simpevarp and in Småland, fracture data from outcrops were collected. A cell mapping system was used. Circular outcrops, parts of outcrops or road cuts were mapped. Fracture characteristics such as, length, fracture termination, fracture intersections, movements foliation, aperture, minerals, orientation and dip, were collected for fracture exceeding 0.5 m in length.

You will find more detailed information about the geological data in the SKB report:
TR 88-06 Description of geological data in SKBs database GEOTAB. Tomas Stark
TR 91-01 Description of geological data in SKBs database GEOTAB, Version 2. Stefan Sehlstedt and Tomas Stark.

7. GSGPHYS: GROUND SURFACE GEOPHYSICAL DATA

During the reconnaissance work for new study sites investigations, geophysical profile measurements were made. The purpose was to localize regional fracture zones. For further investigations at study sites or other investigation sites more detailed studies of fracture zones and rock type distribution were carried out. These measurements are made in grid nets.

The measurements are usually collected on forms or as notes. Magnetic measurements are collected on a small field computer.

The data in the subject GSGPHYS is divided into several methods, consisting of one flyleaf table (F) and one data table (D).

The methods beginning with a P contain profile data, while the others are grid-net data.

Subject: GSGPHYS

This subject includes different geophysical measurements performed on the ground surface. The measurements can be made in grid nets with local coordinates or as separate profiles. The two types are handled separately in the database.

Method	Tables	
APRORAK	APRORAK	
PROTMF	PROTMFF	PROTMFD
PROH	PROHF	PROHD
PVLF	PVLFF	PVLFD
PROIPR	PROIPRF	PROIPRD
PROG	PROGF	PROGD
PRORS	PRORSF	
TMAGF	TMAGFF	TMAGFD
HLEMO	HLEMOF	HLEMOD
HLEMI	HLEMIF	HLEMID
VLFI PH	VLFI PHF	VLFI PHD
VL FQA	VL FQAF	VL FQAD
VLFR	VLFRF	VLFRD
VLFP H	VLFP HF	VLFP HD
GSIP	GSIPF	GSIPD
GSR	GSRF	GSRD

Each data table contain one type of measurement or one component of a measurement. The type of measurement stored in each method is listed below.

- APRORAK: Ground Surface Geophysical Profile Location
This method contain data about areacode, profile idcode and RAK Coordinates.
- PROTMF: Total Magnetic Field Measurements, profile measurements
This method detect differences in magnetic susceptibility. This information is used to locate divergent rock types and zones of oxidation in the bedrock.
- PROH: Horizontal Loop EM (slingram), profile measurements
These measurements indicate the presence of fracture zones and bedrock with high electric conductivity, e.g. graphite gneiss or concentration of sulphides.

An estimation of the dip of the fracture zone can be made from the shape of the anomaly.

Two components are measured, in-phase and out-of phase.

- PVLf: VLF: Profile measurements
This method uses changes in signals from distant radio transmitters to detect fracture zones.

Usually two components are measured, in-phase and quadrature component. If adding a special antenna device it is also possible to measure a resistivity and phase angle component.

- PROIPR: Induced Polarization/Resistivity, profile measurements
These measurements reveal the occurrence of sulfide minerals in disseminated form which is difficult to detect by other geophysical methods. This method is used in connection with the electrical resistivity method and is therefore not used as a matter of routine in site investigations.
- PROG: Gravimetric Measurements, profile measurements
These measurements are used to locate contacts between rock types with different densities. Depth estimations of limited rock bodies with sufficient density contrasts can be made.
- PRORS: Seismic Refraction Measurements, profile measurements
These measurements give the thickness of the overburden and indicate fracture zones if they are wide enough. This method is specially useful at sites with an abundance of electric conductivity clays. In such areas electric and electromagnetic measurements give limited information. The method is performed in individual profiles at the study sites.
- TMAGF: Total Magnetic Field Measurements
Same as PROTMF but measured in grid net.
- HLEMO: Horizontal Loop EM, out-of-phase component
Same as PROH but measured in grid net.
- HLEMI: Horizontal Loop EM, in-phase component
Same as PROH but measured in grid net.
- VLFIPH: VLF: In-phase Component
Same as PVLf but measured in grid net.
- VLFQA: VLF: Quadrature Component
Same as PVLf but measured in grid net.
- VLFR: VLF: Resistivity
Same as PVLf but measured in grid net.
- VLFPH: VLF: Phase Angle
Same as PVLf but measured in grid net.
- GSIP: Ground Surface Induced Polarization
These measurements reveal the occurrence of sulfide minerals in disseminated form which is difficult to detect by other geophysical methods. This method is used in connection with the electrical resistivity method and is therefore not used as a matter of routine in site investigations.

– GSR: Ground Surface Resistivity

Areas with high fracture frequency as well as fracture zones are indicated by electrical resistivity measurements. Bedrock with high electric conductivity, e.g. graphite and sulfide ore minerals, is also indicated. This method is used when other electrical methods are disturbed by power lines, etc.

You will find more detailed information about ground geophysical data in the SKB report:

TR 88–05 Description of geophysical data in SKBs database GEOTAB. Stefan Sehlstedt.

TR 91–02 Description of geophysical data in SKBs database GEOTAB, Version 2. Stefan Sehlstedt.

8. BHGPHYS: GEOPHYSICAL BOREHOLE LOGGING DATA

Geophysical borehole logging is used to localize and identify sections or intervals with varying geophysical characteristics indicating different rock types or structures in the bedrock such as fracture zones, magnetic dikes or other geological boundaries. It is also possible to indicate water movements in the borehole.

The data is registered on forms, strip charts, tapes or cassettes and later transferred to the database. The subject BHGPHYS is divided into several methods, consisting of two flyleaf tables (F1 and F2) and one data table (D). Each method corresponds to one type of measurement.

Subject: BHGPHYS

Method	Tables		
BFRES	BFRESF1	BFRESF2	BFRES D
BFSAL	BFSALF1	BFSALF2	BFSAL D
BFTEMP	BFTEMPF1	BFTEMPF2	BFTEMP D
CALIPER	CALIPF	CALIPD	
DEVANGLE	DEVANGLE		
DIFFR	DIFFRF1	DIFFRF2	DIFFR D
GAMMA	GAMMAF1	GAMMAF2	GAMMA D
GG	GGF1	GGF2	GG D
ICON	ICONF1	CONF2	COND
IP	IPF1	IPF2	PD
IPR	IPRF1	IPRF2	IPR D
LRES	LRESF1	LRESF2	LRES D
MSUS	MSUSF1	MSUSF2	MSUS D
NN	NNF1	NNF2	NND
NRES	NRESF1	NRESF2	NRES D
RADAR	RADARF1	RADARF2	
SLING	SLINGF1	SLINGF2	SLING D
SONIC	SONICF1	SONICF2	SONIC D
SP	SPF1	SPF2	SPD
SPRES	SPRESF1	SPRESF2	SPRES D
TRES	TRESF1	TRESF2	TRES D
TUBEW	TUBEWF1	TUBEWF2	
VLF	VLFF1	VLFF2	VLFD
VTG	VTGF1	VTGF2	VTGD

Each data table contains one type of measurement or one component of a measurement. The type of measurement stored in each method is listed below.

- BFRES: Borehole Fluid Resistivity
The resistivity of the borehole fluid and the temperature are measured simultaneously using the same probe.

From the measurements information concerning water movements in the borehole is yielded.

- BFSAL: Borehole Fluid Salinity
The salinity of the borehole fluid is calculated from the borehole fluid resistivity and temperature. It is presented as equivalent concentration NaCl (ppm).

- **BFTEMP: Borehole Fluid Temperature**
Measured with the same probe as BFRES.
- **CALIPER: Borehole Diameter Measurement**
This tool measures the borehole diameter, thus indicating cavities in the borehole wall.
- **DEVANGLE: Borehole Deviation Measurement**
The declination is measured in a 360 degree clockwise system by a compass needle, where 0 and 360 degrees is north. The inclination is measured in a 90 degree system by a pendulum, where 0 degrees is horizontal and 90 degrees is vertical.
- **DIFFR: Differential Resistance**
Differential resistance will indicate small fractures which increase the diameter of the borehole. This log works as an electric caliper in the absence of conducting minerals. The measurements are quite similar to those from single point resistance, which is usually used.
- **GAMMA: Natural Gamma Radiation**
This probe will measure the natural gamma radiation (micro-Roentgen/h) of the bedrock. The results will give information of the total radioactivity of the rock, i.e. the summation of potassium, uranium and thorium content. Variation in these elements will normally correspond to mineralogical changes in the rock.
- **GG: Gamma–Gamma (density)**
The gamma–gamma (density) tool is used to determine the rock density. In crystalline rock environments the tool are used, mainly, to make lithology determinations.
- **ICON: Inductive Conductivity**
Inductive conductivity can be measured with the susceptibility probe if the conductivity is high enough. No data stored.
- **IP: Induced Polarization (IP)**
The induced polarization indicates the presence of disseminated sulfides and graphite.
- **IPR IP: Resistivity**
Bedrock resistivity may be measured with the IP probe. No data stored.
- **LRES: Lateral Resistivity**
The lateral array has better resolution compared to the normal array (see NRES). It indicates fractured sections in the borehole wall.
- **MSUS: Magnetic Susceptibility**
The magnetic susceptibility gives information about the presence of magnetic minerals in the rock. In crystalline bedrock the most common magnetic mineral is magnetite. Knowing the susceptibility of a rock the magnetite content might be calculated. Rock types often differ in magnetite content and can thus be separated.
- **NN: Neutron–Neutron**
In crystalline rock environments the tool will act as a lithologic log, for

example a mafic dyke will appear stronger or almost as strong as a water bearing fracture zone.

- NRES: Normal Resistivity
With this configuration the apparent resistivity (ohm-m) of the bedrock is measured. The normal resistivity log will indicate zones with anomalous resistivity such as fracture zones, conducting minerals or mineralizations.
- RADAR: Radar Measurement
In the radar technique electromagnetic waves are transmitted through the rock in order to obtain information on structures, such as fracture zones, in the rock mass at large distances from the borehole (0–100 m). It is possible to determine the angle of intersection between the hole and a fracture plane.
- SLING: Slingram
The log is used to detect electrical conductors in the vicinity of the borehole, and it will also give information about how good or bad a conductor is. In low resistivity formations it may also be used to measure the resistivity.
- SONIC: Sonic (Acoustic)
The sonic velocity probe records the time for a compressional elastic wave to travel between the two receivers, in the formation surrounding the borehole. Fractured sections and rock types with different elastic properties will be detected.
- SP: Self Potential (SP)
With the device the natural potential of the rock is measured (V or mV). Natural potentials can be caused by redox processes, diffusion of ions and kinematic processes. Thus, the SP-log gives information about conducting minerals, ion concentration variations and groundwater flow in or out of the borehole. In crystalline rock this log has mainly been used to diagnose conducting minerals.
- SPRES: Single Point Resistance
With this probe the contact resistance (ohm) of the bedrock is measured. The small electrode gives a high resolution. Conducting minerals and individual fractures or cavities in the borehole wall will be detected.
- TRES: True Resistivity
Normal and lateral resistivity measurements are apparent resistivities. Apparent values can be corrected for borehole fluid resistivities and borehole diameter which influences the measurements.
- TUBEW: Tube Wave
In general, there is a good correlation between tube wave sources and sections of high or increased hydraulic conductivity in the borehole. In general terms, it appears that tube waves may be detected from zones with a hydraulic conductivity exceeding $10E-10$ m/s (Stenberg and Olsson, 1985).
- VLF: VLF
The method is used to indicate the presence of electrical conductors in the vicinity of the borehole. Good conductors may be detected at a considerable distance from the borehole. Conductors crossing the borehole can be separated from those which do not.

– VTG: Vertical Temperature Gradient

The vertical temperature gradient is calculated from temperature and borehole orientation and inclination loggings.

You will find more detailed information about geophysical data in the SKB report:
TR 88-05 Description of geophysical data in SKBs database GEOTAB. Stefan Sehlstedt.

TR 91-02 Description of geophysical data in SKBs database GEOTAB, Version 2.
Stefan Sehlstedt.

9. PETRO: PETROPHYSICAL MEASUREMENTS

This subject include the physical properties measured on drill core samples. Petrophysics is a link between geology and geophysics. The measured values are used to correlate anomalies from the geophysical ground surface measurements with rock types observed by the geologist.

The measurements are noted on forms, punched, calculated and stored in the database.

The data in the subject PETRO is stored in one method. This method, PETRO, contains two tables, one flyleaf table (F) and one data table D(D).

Subject: PETRO

Method	Tables	
PETRO	PETROF	PETROD

The following parameters are measured and stored in the method PETRO:

- Density
The density is dependent on the mineralogic composition of a rock sample. The density increases with increasing content of mafic minerals and decreases with increasing content of silica.
- Porosity
Porosity controls the volume of contained water. This means that porosity has great influence on the electric resistivity.
- Magnetic Susceptibility
The magnetic susceptibility gives information about the presence of magnetic minerals in the rock. In crystalline bedrock the most common magnetic mineral is magnetite. Knowing the susceptibility of a rock the magnetite content might be calculated. Rock types often differ in magnetite content and can thus be separated.
- Magnetic Remanence
This is the permanent magnetic field (vector) created when the rock was formed. In highly magnetic rocks this information can be used to determine when the rock was formed.
- Q-value
This is a quota describing the relation between magnetic susceptibility and magnetic remanence.
- Induced Polarization
High induced polarization effect indicates the presence of disseminated sulfides or graphite.
- Resistivity
The electric resistivity is influenced by water in micro fractures and pores in a rock sample. It decreases with increasing water content.

You will find more information concerning geophysical data in the SKB report:

SKB TR88-05. Description of geophysical data in the SKB database GEOTAB. Stefan Sehlstedt. SKB

TR91-02. Description of geophysical data in the SKB database GEOTAB, Version 2. Stefan Sehlstedt.

10. CHEMICAL: CHEMICAL CHARACTERIZATION OF DEEP GROUNDWATER

The chemical composition of the groundwater will determine the corrosion of the waste canisters and the dissolution of the waste form. It will also influence the migration of released radionuclides. The chemical character of the groundwater is therefore an important factor for the safety assessment of a subsurface repository.

The main part of the chemical investigation is performed in a mobile field laboratory located at the investigation site. The groundwater is pumped to the surface and led through a tubing system directly into the laboratory.

Several water conductive sections are sampled in each investigated borehole and the water is analyzed. Each sampled section is isolated from the rest of the borehole using packer equipment.

The chemical characterization of the groundwater can be divided into three parts.

- a Chemical analyses of major components and trace metals by standard water analyses methods.
- b Computer controlled measurements.
- c Special analyses which requires specialized laboratories.

The great number of data obtained from measurements and analyses is subjected to quality control and reduction and stored in GEOTAB.

The chemical data group (subject) in GEOTAB is called CHEMI. It is divided into subgroups (methods) named WATER, SPECAN, GWANAL, SYANAL, GWMEAS, GAS and ISOTOPE. Each method consists of several data tables.

Subject: CHEMI

Method	Tables				
GWMEAS	GWMEASF1	GWMEASF2	GWREDOX	GWPHETC	
GAS	GASF1	GASF2	GAS2		
GWANAL	GWANALF1	GWANALF2	GWMAIN	GWREM	
ISOTOPE	ISOTOPF1	ISOTOPF2	ISOTOPE2		
SPECAN	SPECANF	ISOTOPE	RRUT	GAS	PARTIC
SYANAL	SYANALF1	SYANALF2	SYMAIN	SYREM	
WATER	WATERF1	WATERF2,	WATERF3	WATERF4	REDOX
	PHETC	MAIN	REM	EQUIV	

Methods with short description are listed below:

- GWMEAS: Automatically registered groundwater measurements. The method contains measurements starting from 1990.
- GAS: Determinations of gas content in groundwater. The sampling is performed using a specially constructed gas sampler for sampling within the borehole section.
- GWANAL: Groundwater analyses in core drilled and percussion drilled boreholes. Analyses starting from 1990.

- ISOTOPE: Isotope determinations and related elements in groundwater, including ^{18}O , ^2H , ^3H , ^{14}C , natural Uranium, Uranium isotope ratio, ^{222}Rn , ^{226}Ra and Th. The method contains determinations starting from 1990.
- SPECAN: Special analyses of deep groundwater. The method includes tables for gas content, isotope determinations, determinations of particulate matters and determinations of Thorium, Uranium, Radium and Radon. The method includes data prior to 1990.
- SYANAL: Groundwater analyses from sounding boreholes and leakage points in the rock tunnel at Äspö. The method contain analyses starting from 1990.
- WATER: Groundwater analyses and automatically registered measurement. The method includes data prior to 1990.

You will find more detailed information about chemical data in the SKB reports:

TR 83-17. Analysis of groundwater from deep boreholes in Gideå. Sif Laurent
TR 83-19. Analysis of groundwater from deep boreholes in Fjällveden. Sif Laurent
TR 83-41 Analysis of groundwater from deep boreholes in Svartboberget. Sif Laurent
TR 83-70. Analysis of groundwater from deep boreholes in Kamlunge. Sif Laurent
TR 86-17 Analysis of groundwater from deep boreholes in Kamlunge. Sif Laurent
TR 87-07. Deep groundwater chemistry. Peter Wikberg, Karin Axelsson, Folke Fredlund
PR 25-89-14. Chemical characterization of deep groundwater on Äspö, Ann-Chatrin Nilsson

11. TRACER: TRACER TESTS

The result from the tracer test are divided into five different methods and each method is presented separately in the database.

In addition there is one method containing check tables or lexicon tables for the other five methods.

Subject: TRACER

Method	Tables			
DILUTION	DILUTF1	DILUTF2	DILUTF3	DILUTF4
	DILUTF5	DILUGEO	DILUTD	
	DILUTCD			
DIPOL	DIPOLF1	DIPOLF2	DIPOLF3	DIPOLF4
	DIPOLTEM	DIPOLCON	DIPOLEH	DIPOLGEO
	DIPOLQD	DIPOLCD		
FLUSH	FLUSHF1	FLUSHF2	FLUSHF3	FLUSHF4
	FLUSHTEM	FLUSHCON	FLUSHEH	FLUSHGEO
	FLUSHQD	FLUSHCD1	FLUSHCD2	
RADCON	RADCONF1	RADCONF2	RADCONF3	RADCONF4
	RADCOTEM	RADCOCON	RADCOEH	RADCOGEO
	RADCONQD	RADCOCD1	RADCOCD2	RADCOCD3
	RADCOCD4			
RADDIV	RADDIVF1	RADDIVF2	RADDIVF3	RADDIVF4
	RADDIGEO	RADDIVIP	RADDIVIQ	RADDICD1
	RADDICD2	RADDICD3	RADDICD4	
TRCHECK	TRACECOD	INJECODE		

Methods with a short description are listed below:

- DILUTION: Dilution test
The point dilution method enables the determination of ground water flow in situ, in fractures and fracture zones under natural hydraulic gradient conditions, and in the direction of the natural ground water flow. In this method the tracer is introduced as a homogeneous pulse into a borehole or a test section of borehole sealed off by rubber packers. The tracer will be diluted due to the ground water from the fracture zone flowing through the borehole.
- DIPOLE: Dipole test
The dipole test, also referred to as the doublet or two-well test, is performed by creating a dipole flow field between a pump well and an injection well. The flow field is created either by recirculating the water withdrawn from the pump well, back into the injection well or by injecting and discharging water without recirculation.
- FLUSHING: Flushing water test
During drilling, of cored boreholes flushing water is used in order to cool the drill bit and to flush out the drilling debris. The water is continuously pumped from a water supply well into a storage tank where it is labelled with a tracer, i e the fluorescent dye Uranine (sodium fluorescein). The primary aim of the method is to establish if the drilled borehole and the supply well

are hydraulically connected. This is made by sampling the water from the supply well before and after tracer labelling. Prior to drilling, samples for background readings of tracer is taken in water supply well.

- RADCON: Radially converging test
In a radially converging flow field, created by pumping a well or a sealed off section of a well, tracers are injected in one or several injection wells. The injection wells may be sealed off in one or more injection intervals. Sampling of the pumping well is performed with an automatic sampling equipment and tracer breakthrough curves are obtained by analyzing the samples for tracer contents.
- RADDIV: Radially diverging test
In a radially diverging flow field, created by injecting water in a borehole or a sealed off section of a borehole, tracers are added. Sampling is performed in one or several detection boreholes or sealed off sections of the boreholes.
- TRCHECK: Check tables
During radially converging and radially diverging tests, different tracers can be used during one test where start date, injection or detection borehole and upper and lower limit of test section are the same. Then it is necessary to use the tracer name as a search criteria in order separate calculated data from the same test, which only differs in tracer name.

You will find more detailed information about the tracer data in the SKB report:
TR 91-05 Description of tracer data in SKBs database GEOTAB, Version 1. Andersson, Gerlach.

12. HIERARCHICAL DATA RETRIEVAL

Hierarchical data retrieval (top – down) can be done by show/enter transaction.

Enter/Show Data

When you enter enter/show data transaction a menu will show up on screen.

SKB GEODATABASE

1. Input new data
2. Update data
3. Show data
4. Describe method
5. Output to sequential file

Select:

Subject:	Method:	Table:
Subject:		
Method:		
Table:		

The program first asks for a menu choice and then for a subject, a method and a tablename.

The subject is the top level. It is the type of measurement (eg. hydro,chemi etc). A list of valid names will pop up if you enter a \$ as the first character in the field. You may leave the subject blank if you wish.

Method is the second level. You are expected to give the name of the method you are interested in. The \$ gives you a list of valid names. If you have selected a subject, only methods belonging to that subject are shown then.

Records in tables are the third and following levels. You can choose a certain table in the specified method by entering the table name or if you wish to start with the first table, just enter RETURN.

Alternative 1,2 and 3 shows a serie of pictures, one for each flyleaf and data table in the method. Alt. 4 gives you a short description of the method and 5 asks for a sequential file to dump the contents of the selected table in.

13. DIRECT DATA RETRIEVAL

In GEOTAB it is possible to make direct data retrieval. The tools that makes this possible are QL (Mimer Query Language) and/or RQL (GEOTAB's Query Language). Both QL and RQL provides you with a set of commands which allows you to retrieve data direct from GEOTAB.

To retrieve data from GEOTAB it is essential to know a little about the different objects in the database as tables, columns and keys.

Tables, Columns And Rows

Data in GEOTAB is organized in tables, which consist of horizontal rows and vertical columns. Each field, defined by the intersection of a row and a column, contains one item of data. All fields in one column are of the same physical length and contain the same type of information, identified collectively by the column name. A table may for example have columns for surname, first names, date of birth, address and telephone number.

The fields in one row together contain information for one specific item (or post). Thus a row may borehole id, length along borehole, date and measured data. A field does not have to be filled if for example one measurement is missing. Empty fields have a special NULL value in MIMER.

The maximum size of a MIMER table depends on the host computer system, but the limits on both the length and number of rows are so large that they seldom become a practical limitation.

Primary And Secondary Keys

Rows are not named: instead they are identified by the contents of one or more columns comprising the primary key. This information is unique to the row, so that no two rows in a given table can have the same primary key. This sometimes means that an extra column has to be used for an ID-number for the row, when the other information in the row is not sufficiently unique.

In MIMER tables, the primary key column(s) are always the first columns in the table. Facilities for changing the content of the primary key columns are restricted.

MIMER automatically sorts the rows in a table in (alphanumerical or numerical) order of their primary key, so that retrieval of data is very efficient if the primary key is specified. Searches for data in columns other than the primary key are performed sequentially through the table.

However, any column other than the first primary key column may be temporarily defined as a secondary key in a MIMER application, which means that MIMER automatically maintains an index sorted on the basis of the secondary key and referring to the primary key of the original table.

Searches are performed in the secondary index table whenever this improves the efficiency of data retrieval.

Selecting Data From A Table

You can select data from a table with three different choices.

1. Entry/Show data
2. RQL – Retrieval Query Language
3. QL – Mimer Query Language

In Enter/show data you choose a subject, method and optional table. You will then get a picture of a table with leading text strings instead of column names. It's only possible to inspect one record at a time.

The second choice above is RQL which makes it possible to select data from a table with the select command.

The third choice is the GET command in QL. The GET command in QL retrieves data from one or more tables. The search of specific rows is governed by condition clause. Both select command in RQL and GET command in QL can retrieve data from two tables at a time.

This can be done by using RQL, selecting data from two tables, storing the result in a temporary table and repeating the select command with the temptable and the third table. Repeating this procedure it is possible to retrieve data from more than two tables at a time.

Using MIMER QL, it is possible to select data in one operation. The syntax is painful however. For time-consuming selects (big tables) it can be worth to try this approach.

Doing Calculations In Search Process

It's possible to make calculation in search process. You can make calculation between columns and present the result in a new calculated column.

14. POSTPROCESSING

Output Formats

When selecting data the result can be transferred into different formats:

- Ascii file format
- CSV file format
- DBASEIII+ file format
- Dif file format
- HPGL file format
- MIO file format
- NCSS file format
- SDI file format
- SSC file format
- SYLK file format
- Symphony file format

Transfer Technics

It's possible to transfer files to and from Vax Vms system both from RQL. It can be done through the transfer command in RQL or with the kermit facility in DCL.

Kermit Facility

Vax Vms kermit can be reached from either geotab's main menu or directly in DCL, outside geotab.

Transfer Command

The command can be used to send files from the VAX to your local computer (PC). You must run a program capable of the Kermit file transfer protocol. If you are using VTKermit on a IBM-PC or compatible, you only need to enter the Transfer command and the file will be transferred. On other implementations of Kermit you must exit back to command level on your local Kermit and issue a Receive command, after entering the Transfer command.

Syntax

TTransfer <filename>

15. GETTING HELP

There are several help functions in GEOTAB. Use them !!
These are:

? – is used when you need help.

\$ – gives you a list of valid alternatives.

Help command in RQL.

The HELP command displays the help topics for RQL. The command uses VMS Help Utility. Use the question mark (?) in response to the Topic? or Subtopic? prompts to redisplay the list of topics available at the current level. For more information about the Help Utility, refer to the VMS Utility manual.

Syntax

Help <command>

CTRL/R command in GEOTAB makes it possible to enter a RQL command when you are working in another menu then RQL.

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TR 79-28

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Stockholm, June 1985

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TR 85-20

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Including Summaries of Technical Reports Issued during 1987

Stockholm, May 1988

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