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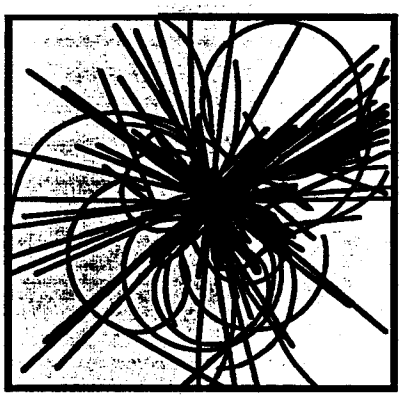
Project No. 87-888-0021
Report No. SSC-GR-70
August 1990

Rev. 0

Superconducting Super Collider
Project Specific
gINT Database and Manual



Prepared by: The Earth Technology Corporation
Long Beach, California

Prepared for: RTK a joint venture
Oakland, California

Project No. 87-888-0022
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SUPER CONDUCTING SUPER COLLIDER

PROJECT SPECIFIC gINT DATABASE AND MANUAL

THE EARTH TECHNOLOGY CORPORATION
LONG BEACH, CALIFORNIA

Prepared for:
RTK JOINT VENTURE
OAKLAND, CALIFORNIA

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INTRODUCTION

The purpose of this SSC project specific data base manual is to supplement the documentation of the gEOTECHNICAL INTegrator (gINT™).

As shown in Figure 1, each boring log is a compilation of several information sets stored in the gINT data base. These information sets may also be accessed directly through tabulations, graphs, and profiles. The data base is organized as a hierarchical structure shown in Figure 2. This manual describes the data base and the program use on a "room" basis (a pattern similar to gINT itself). Figure 3 indicates the data base output structure. It is important to recognize that only the most immediate features available in the data base are described herewith. A broader range of options is possible on an as-needed basis through an advanced knowledge of the gINT software capabilities.

The manual also provides an explanation on how the geologic and geomechanic data were compiled and entered in the data base. Hence, it supplements the more extensive descriptions of the geologic features and geomechanical properties of the subsurface materials that have been addressed elsewhere, and should be used in conjunction with other relevant documents.

The Earth Technology coring procedure (F-3-1) is attached in Appendix A. SSC project-specific coring procedures were also used in addition of F-3-1 and are documented in Appendix B.

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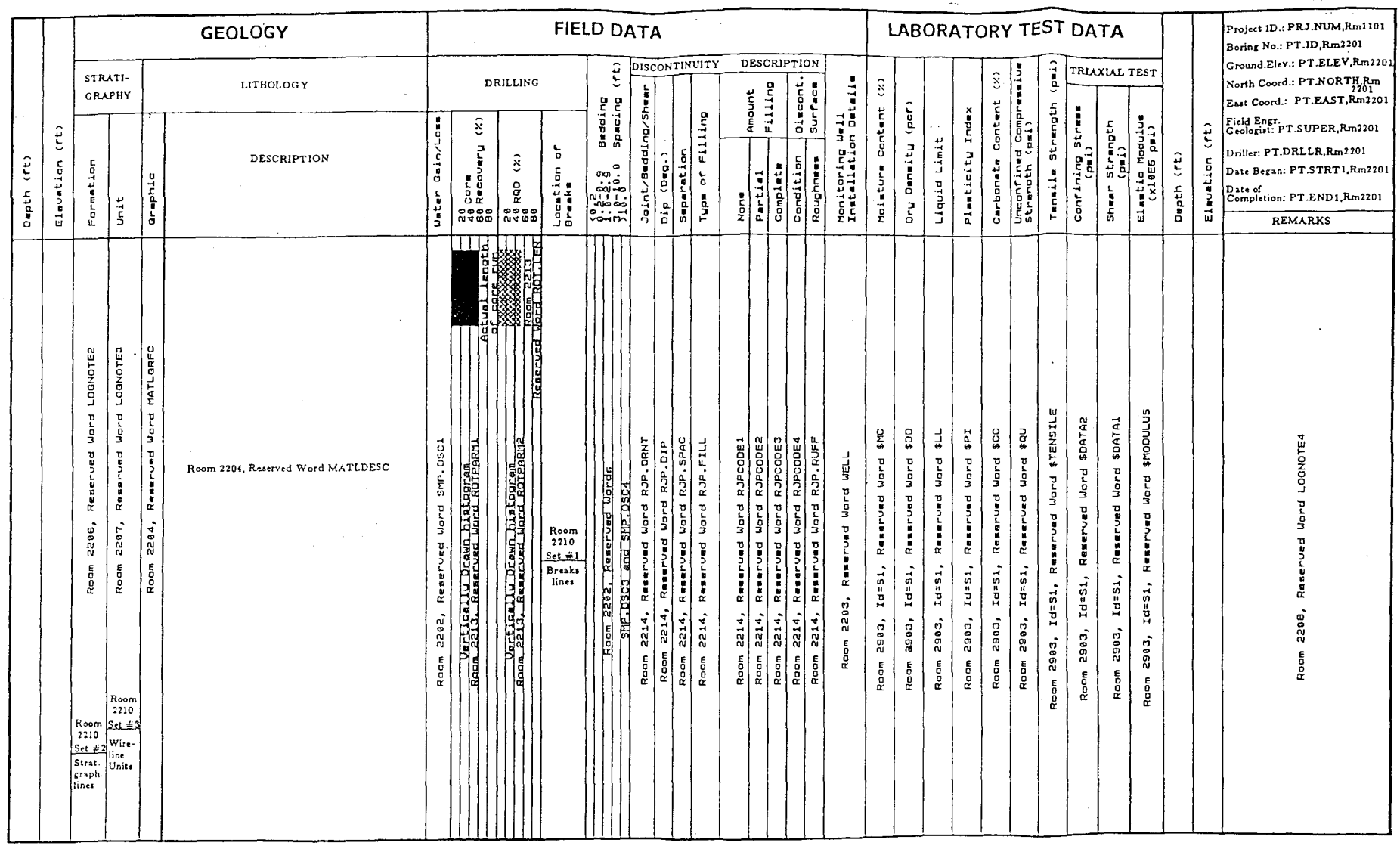

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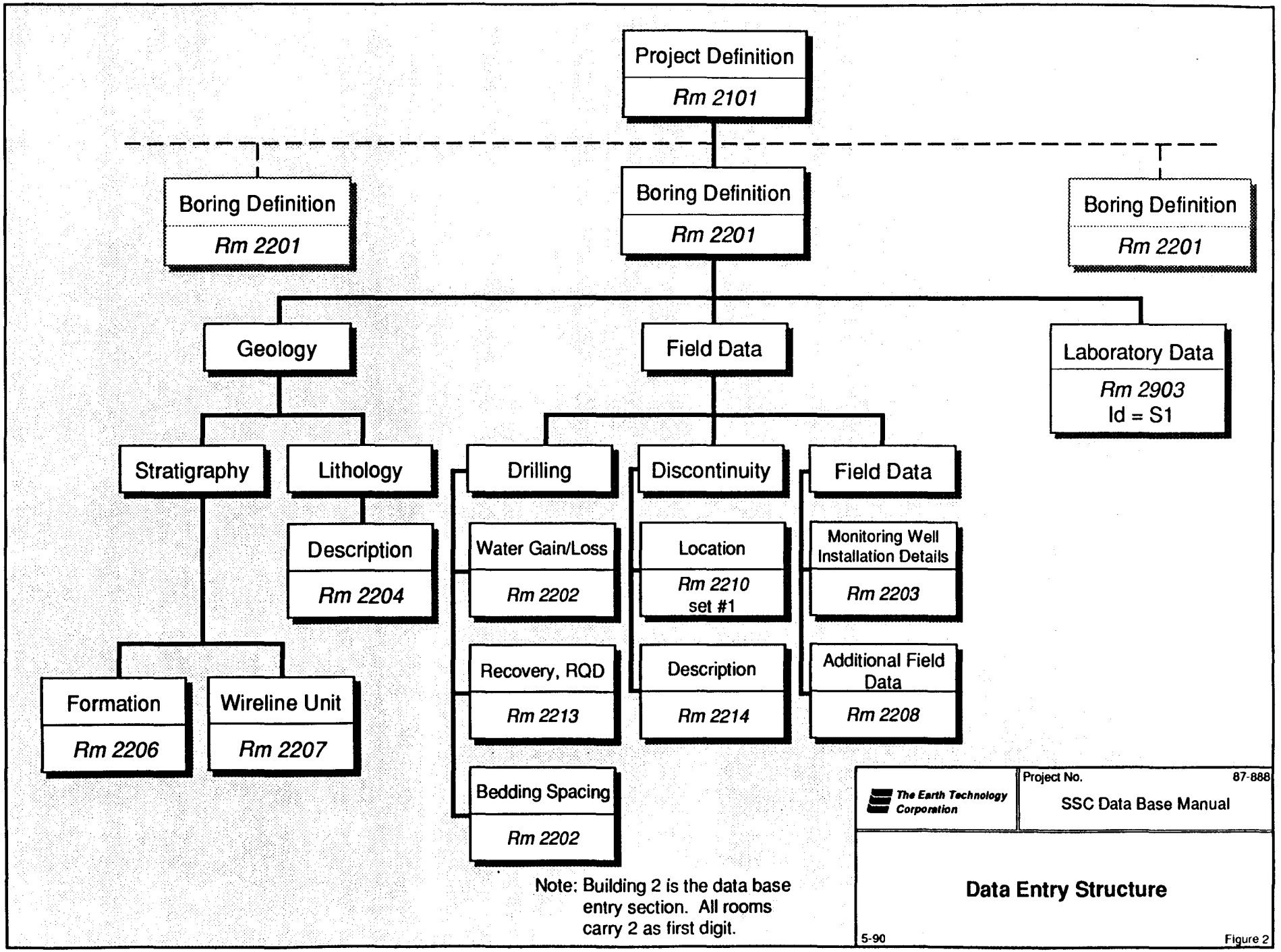
Boring Identifier
Room 2201
Reserved word PT.ID

SSC Data Base Manual
Figure 1

SHEET PG OF
BORING PT.ID,Rm2201
Superconducting Super Collider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Note: Building 2 is the data base entry section. All rooms carry 2 as first digit.
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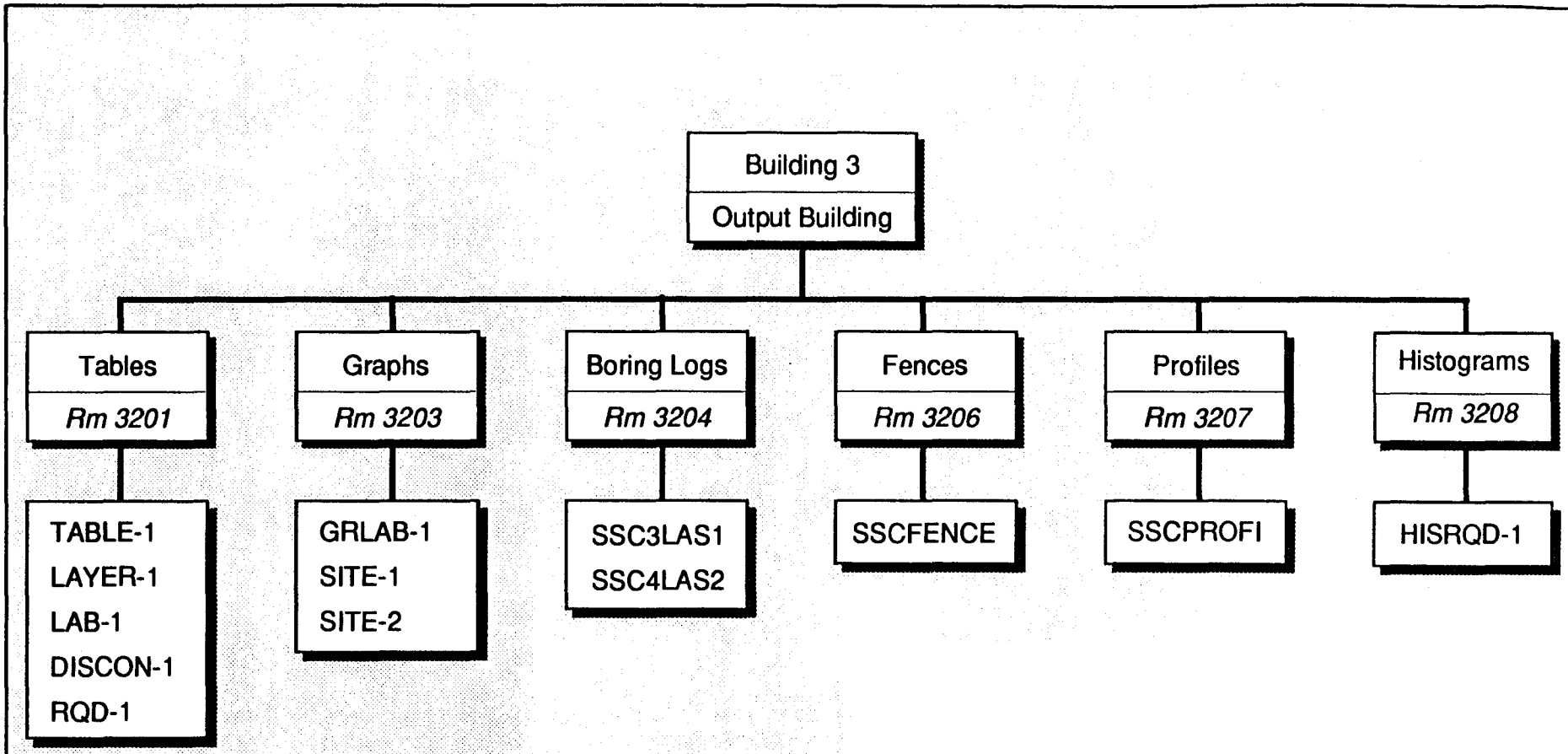

Note: Building 3 is the data base output section. All rooms carry 3 as first digit.

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Data Output Structure

ROOM 2101 - PROJECT DEFINITION

The data stored in this room are the project ID and the project number. The project ID identifies the project and allow the user to create a subdirectory carrying the project ID as name (i.e., SSC project files are stored in subdirectory \SSC).

Reserved Word	PRJ.ID	(= SSC)
Reserved Word	PRJ.NUM	(= 87888; Earth Technology project number)

ROOM 2201 - BOREHOLE POINT DEFINITION

Data are compiled from lithologic logs and geologist's field book (as needed).

Explanation	gINT Screen	Reserved Word	Remarks
Date drilling commences	Started	PT.STRT1	
Date borehole is plugged or installed as a monitoring well	Ended	PT.END1	
Northing coordinates	North	PT.NORTH	As surveyed by surveyors, in feet
Easting coordinates	East	PT.EAST	As surveyed by surveyors, in feet
Ground Surface Elevation	Elevation	PT.ELEV	As surveyed by surveyors, in feet
Drilling Geologist	Supervisor	PT.SUPER	
Contractor	Driller	PT.DRLLR	MJA or SWL
Vertical depth of borehole	Depth	PT.DEPTH	In feet

ROOM 2202 - SAMPLE DATA

Data are compiled from lithologic logs and geologist's field book (as needed). This room is used for data related to a depth range. Data appear as vertically drawn histograms on the log.

Explanation	gINT Screen	Reserved Word	Remarks
Top depth of data range	TOP DEPTH	SMP.TOPD	In feet
Length of data range (Top depth - Bottom depth)	LENGTH	SMP.LEN	In feet
Not Used	TYPE BLOW COUNT N COMP.*+ REC % RQD % SCR %		
Water gain/loss in the depth range	SMP.DSC1+	SMP.DSC1	
Not Used	SMP.DSC2+	SMP.DSC2	
Bedding Spacing (in feet)	SMP.DSC3+ SMP.DSC4+	SMP.DSC3 SMP.DSC4	Numeral codes for bedding spacing are indicated below

Numeral Codes for Bedding Spacing		
Bedding Spacing (in feet)	SMP.DSC1 Value	SMP.DSC2 Value
<0.2	0	1
0.2 to 0.9	1	2
1.0 to 2.9	2	3
3.0 to 10.0	3	4
10.0 <	4	5

ROOM 2203 - MONITORING WELL INSTALLATION DETAILS

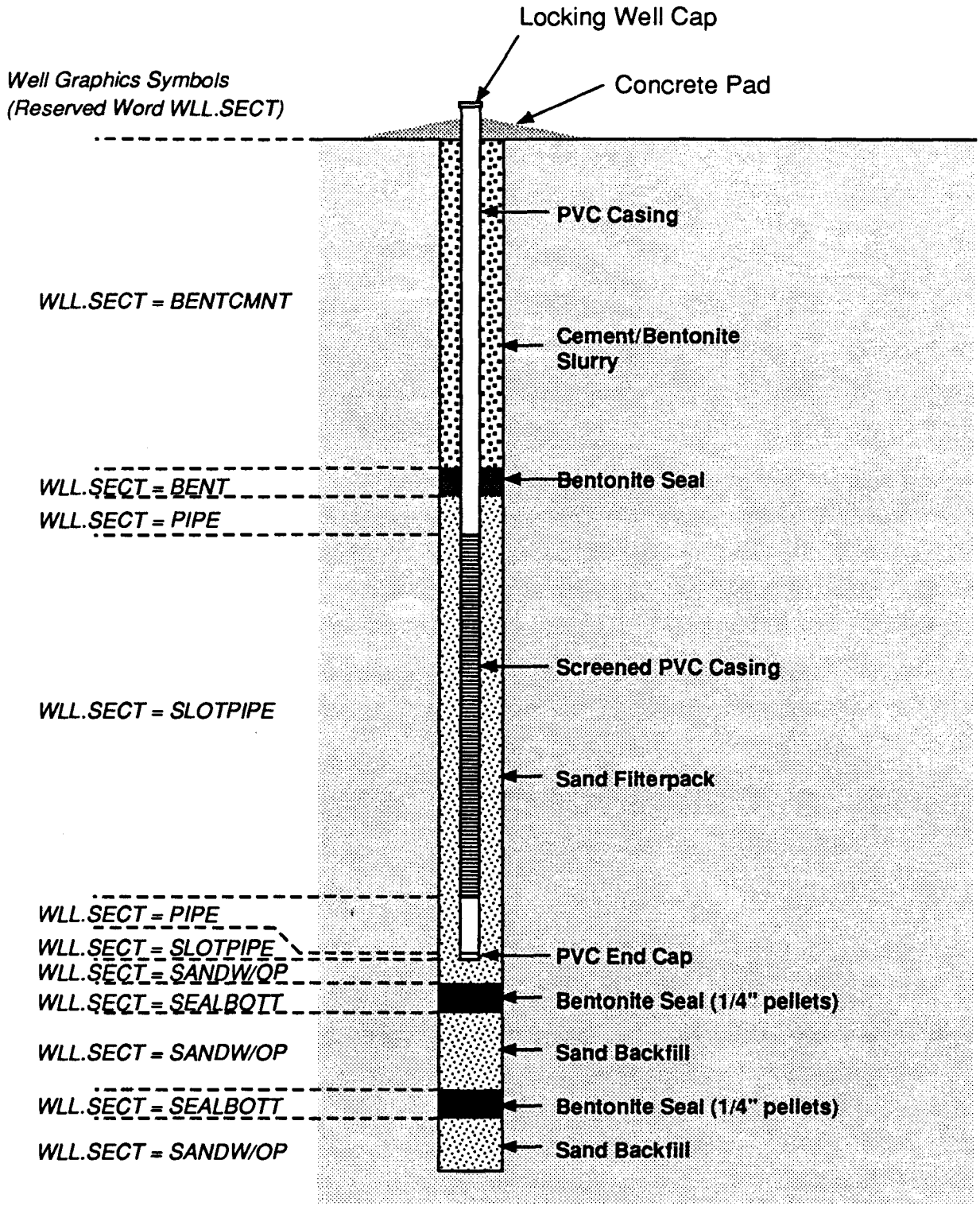
This room is used to enter well graphic logs. Data are compiled from "As Built" well installation diagrams. Each section of a well is defined by its bottom depth and symbol code.

Figure 2203-1 indicates the well symbol codes used in the SSC project for a typical monitoring well diagram.

Reserved Words WLL.BDPH, WLL.SECT, and WELL.

Notes: 1) This room uses a horizontally scrolling screen, so there are more data sets than are shown on the screen.

2) Centralizers were installed in some wells but are not shown on the details column on the boring log.



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Typical Monitoring Well Diagram

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Figure 4

ROOM 2204 - MATERIAL DESCRIPTION

MATERIAL DESCRIPTION - includes typed description of lithology encountered and depths at which it occurs.

DEPTH - refers to actual depth line in the template to which text is entered. It should be noted that the GINT template has a maximum capability of 40 feet per page (vertical scale of approximately 1" = 5').

GRAPHIC COMMAND - entered in material description column, but not printed on log during printout, indicated by the period as the first character of the line.

- Appears as .T=X M=XXXXXXXX G=X

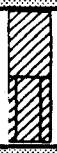
- For each stratigraphic unit and condition, a corresponding symbol has been assigned.

  T=X Draws a horizontal line between material description (text)
  Possible values for X are:
  0 Draws no horizontal line
  1 Draws solid horizontal line
  5 Draws dashed horizontal line

  M=XXXXXXXX Draws pattern above the line in the graphic column.
  (See Figure 2204-1 for available graphic symbols).

  G=X Draws a horizontal line in graphic column.
  Possible values for X are:
  0 No line
  1 Solid horizontal line
  5 Dashed horizontal line

Data is compiled from lithologic logs. The lithologic units mentioned in the material description are further described in the SSC site reference stratigraphic column (Earth Technology, February 1990).

Graphic Symbols	Lithologic Descriptions	Stratigraphic Formations
	*Clay (M = CL)* *Silty Clay (M = CLML)*	**Residual Soils and Alluvial Deposits**
	*Weathered Taylor Marl (M = WEAMARL)* *Unweathered Taylor Marl (M = MARL)*	**Taylor Marl (Ozan Formation)**
	*Weathered Austin Chalk, Limestone (M = WEALIMES)* *Unweathered Austin Chalk, Limestone (M = LIMESTON)* *Argillaceous, Shaley Austin Chalk, Limestone (M = LIMESHAL)* *Bentonitic Shale (M = BENS)* *Bentonite (M = BENT)*	**Austin Chalk, Limestone**
	*Eagle Ford Shale (M = SHALE)*	**Eagle Ford Shale, Calcareous Shale**

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Soil/Rock Symbols for Boring Logs

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Figure 5

ROOM 2206 - STRATIGRAPHIC FORMATION

Stratigraphic Formation	Abbreviated Designation on Log
Top Soil, Alluvial Deposit	Qal
Top Soil, Residual Soil	Qres
Taylor Marl (Ozan Formation)	Ko
Austin Chalk	Kau
Eagle Ford Shale	Ksb

DEPTH - refers to actual depth line in the template to which the abbreviated stratigraphic formation designation is entered.

Reserved Word LOGNOTE2

Data is compiled from lithologic log. Stratigraphic formations are also described in the SSC site reference stratigraphic column (Earth Technology, February 1990).

Stratigraphic Formations:

Alluvial Deposit	Light brown to tan, sandy clay, may contain limestone fragments with organic debris in upper horizons. Deposited by stream or running water.
Residual Soils	Clay, slightly silty, dark brown to gray, calcareous. Containing residual from underlying bedrock.
Taylor Marl (Ozan Formation)	Medium gray to bluish black shale, firm, fissile, occasional fossil fragments and calcite seams.
Austin Chalk	Limestone, moderately to medium hard, fresh, gray to light gray, slightly to moderately argillaceous and shaley interbeds, occasional pyrite inclusions and shell fragments.
Eagle Ford Shale	Calcareous shale, dark gray to black, soft to medium hard, may contain thin calcite seams as well as calcite and pyrite nodules.

ROOM 2207 - STRATIGRAPHIC WIRELINE UNIT

Wireline units are a geophysical signature for a particular stratigraphic unit that is correlated between different borings. In this case, Single Point Resistivity and Natural Gamma wireline logs and their corresponding lithologic logs were compared to further define contacts, marker beds and other distinct aspects of subsurface bedrock. For some of the site formations, particularly the Austin Chalk, the wireline units are more distinctive and traceable than the visible lithology.

The Taylor Marl has been divided into 3 wireline stratigraphic units, the Austin Chalk has been divided into 13 wireline stratigraphic units, and the Eagle Ford Shale has been divided into 3 wireline stratigraphic units. The wireline units for the Taylor, Austin, and Eagle Ford have been given an alphabetic prefix of T, A, and E, respectively, followed by a numeric suffix that increases with increasing geologic age.

Abbreviated designation in log	Corresponding Stratigraphic Formation
T-21	Taylor Marl
T-22	Taylor Marl
T-23	Taylor Marl
A-15	Austin Chalk
A-16	Austin Chalk
A-17	Austin Chalk
A-18	Austin Chalk
A-19	Austin Chalk
A-20	Austin Chalk
A-21	Austin Chalk
A-22	Austin Chalk
A-23	Austin Chalk
A-24	Austin Chalk (Lower)
BM	Bentonite (Marker bed)
A-25	Austin Chalk (Lower)
A-26	Austin Chalk (Lower)
A-27	Austin Chalk (Lower)
FB	Transition Zone (Fish bed, Shaley l.s)
E-20	Eagle Ford Shale
E-21	Eagle Ford Shale
E-22	Eagle Ford Shale

DEPTH - refers to actual depth line in the template to which the abbreviated wireline unit designation is entered.

Reserved Word LOGNOTE3

ROOM 2208 - REMARKS

Field-related information not reported elsewhere are compiled from lithologic log. These include casing depth, intermediate start and stop drilling dates, additional field test (such as conductivity test), and problems during drilling and/or core recovery. Monitoring well installation information is also included.

DEPTH - refers to actual depth line to which the remark is entered except when referring to data on hydraulic conductivity values.

Reserved Word LOGNOTE4

ROOM 2210 - HORIZONTAL LINES ON LOG

Location of breaks: (Set #1)	horizontal lines drawn in this column of the log identify the location of naturally occurring breaks (i.e., bedding, joints, and shears). It should be noted that mechanical (drilling-caused) breaks are not included. In the chalk, the bedding is defined by more argillaceous layers in the otherwise monotonous chalk. In these instances, bedding breaks are identified at mid-layer depth.
Stratigraphic Formation: (Set #2)	horizontal lines drawn in this column of the log identify the contact between stratigraphic formations.
Stratigraphic Unit: (Set #3)	horizontal lines drawn in this column of the log differentiate between wireline units.

DEPTH - refer to actual depth line to which a horizontal line will be drawn on the log.

ROOM 2213 - DEPTH RANGE DATA

Explanation	gINT Screen	Reserved Word	Remarks
Depth of top of core	Top Depth	RDT.TOPD	(in feet)
Actual length of core run	Length	RDT.LEN	(in feet)
Percentage of core recovered	RDTPARM1	RDTPARM1	(percentage)
Rock quality parameter in which the lengths of all pieces of core greater than twice the diameter are summed and then divided by total length drilled	RDTPARM2	RDTPARM2	(percentage)

NOTE: PERCENT RQD $\leq$ PERCENT REC.

Data are compiled from lithologic log.

ROOM 2214 - ROCK JOINTING PROPERTIES

Discontinuities, which have been identified by a horizontal line (Set #1, Room 2210), in the "location of breaks" column at a given depth, are further described in this room.

1-Discontinuity Type: Reserved Word RJP.ORNT

Bedding planes are identified in the chalk by variations in clay content, and are not an actual plane of separation of the rock core. The shale and marl by definition have pervasive thin beds; hence, no attempt is made to note bedding planes in these units: RJP.ORNT=B

Shears (S) are non-bedding, naturally occurring discontinuities showing apparent displacement. They are identified only when slickensided or striated discontinuity surfaces have been described: RJP.ORNT=S

Joints (J) are non-bedding, naturally occurring discontinuities showing no apparent displacement between surface planes (i.e., all separating, naturally occurring discontinuities not identified as Shears): RJP.ORNT=J

All discontinuities located by a line (Room 2210, Set #1) in the "location of breaks" column are classified within these three categories.

2-Discontinuity Dip Angle: Reserved Word RSP.DIP

Data compiled from lithologic log.

3-Discontinuity Separation: Reserved Word RJP.SPAC

Data compiled from lithologic log. This field is left blank for bedding discontinuities.

Description	Separation of Wall (mm)	RJP.SPAC Value
Closed	0	C
Very Narrow	0 - 0.1	VN
Narrow	>0.1 - 1.0	N
Wide	>1.0 - 5.0	W
Very Wide	>5.0	VW

ROOM 2214 continued

4-Type of Filling: Reserved Word RJP.FILL

Data are compiled from lithologic logs. This field is left blank for bedding discontinuities.

Description	RJP.FILL Value
Calcite Clay Pyrite	Calcite Clay Pyrite

5-Amount of Filling: Reserved Word RJPCODE1, RJPCODE2, or RJPCODE3.

Data are compiled from lithologic logs. This field is left blank for bedding discontinuities.

Description	Definition	Amount of Filling		
		None	Partial	Complete
		RJPCODE1 Value	RJPCODE2 Value	RJPCODE3 Value
Clean	No fracture filling material.	X		
Stained	Coloration of rock only. No filling material.	X		
Partially Filled	Fracture partially filled with recognizable filling material.		X	
Completely Filled	Fracture completely filled with recognizable filling material.			X

ROOM 2214 continued

6-Discontinuity Surface Condition: Reserved Word RJPCODE4

Data are compiled from lithologic logs. This field is left blank for bedding discontinuities.

RJPCODE4 Value	Description	F-3-1 Procedure Descriptor
S	Fresh: no visible sign of weathering	I
A	Faintly weathered: weathering limited to the surface of major discontinuites.	II
A	Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.	III

7-Discontinuity Surface Roughness: Reserved Word RJP.RUFF

Data are compiled from lithologic logs. This field is left blank for bedding discontinuities.

Classification	Description	RJP.RUFF Value
Smooth	Appears smooth and is essentially smooth to the touch. May be slickensided.	S
Slightly Rough	Asperities (undulations) on the discontinuity surfaces are visible and can be distinctly felt.	SR
Medium Rough	Asperities are clearly visible and discontinuity surface feels abrasive.	MR
Rough	Large angular asperities can be seen. Some ridges and high angle steps evident.	R
Very Rough	Near vertical steps and ridges occur on the discontinuity surface.	VR

ROOM 2214 continued

Discontinuity Description Summary (Room 2214)

Explanation	gINT Screen	Reserved Word	Possible Values	Remarks
Discontinuity type	ORIENT TO DIP	RJP.ORNT	B, S, or J	
Discontinuity Dip Angle	DIP	RJP.DIP	0 to 90	
Discontinuity Separation	SPACING	RJP.SPAC	C, VN, N, W, or VW	Left blank in case of bedding discontinuity
Type of Filling	FILLING	RJP.FILL	Calcite, Clay, or Pyrite	Left blank in case of bedding discontinuity
Amount of Filling: None	RJPCODE1	RJPCODE1	X or blank	3 columns left blank only in case of bedding discontinuity
Amount of Filling: Partial	RJPCODE2	RJPCODE2	X or blank	
Amount of Filling: Complete	RJPCODE3	RJPCODE3	X or blank	
Separating Discontinuity Surface Condition	RJPCODE4	RJPCODE4	S or A	Left blank in case of bedding discontinuity (Data will be updated in Rev. 1)
Separating Discontinuity Surface Roughness	ROUGHNESS	RJP.RUFF	S, SR, MR, R, or VR	Left blank in case of bedding discontinuity

Note: Unless specified in the remarks column, all data entries should have only one possible value.

ROOM 2903 - (ID=S1) LABORATORY DATA

Data are compiled from the boring summary sheet issued after reduction, compilation, and validation of laboratory data. Laboratory manuals issued by Southwestern Laboratories (SWL) and Mason-Johnston & Associates (MJA) describe all procedures used for the geomechanical testing program reported in the boring logs.

gINT Screen	Explanation	Reserved Word	Remarks
MOIST. CONTENT	Moisture content	$MC	percentage
DRY DENSITY	Dry density	$DD	in pcf
LIQUID LIMIT	Liquid limit	$LL	percentage
PLASTIC INDEX	Plasticity index	$PI	percentage
CARBONATE CONT	Carbonate content	$CC	percentage
UNCONF COMP STR	Unconfined compressive strength	$QU	in psi
ELASTIC MODULUS	Tangent Young's modulus (E_{50})	$MODULUS	in 10^5 psi
TENSIL STRENGTH	Brazil tensile strength	$TENSILE	in psi
COHESION	Not used	$COHSN	--
PHI	Not used	$PHI	--
DATA1	Shear strength defined as one-half of deviatoric stress at failure during triaxial compression 1/2 ($\sigma_1 - \sigma_3$)	$DATA1	in psi
DATA2	Confining pressure during triaxial compression	$DATA2	in psi
DATA3	Not used	$DATA3	--
ALPHA1	Not used	$ALPHA1	--

ROOM 3201 - TABLE OUTPUT

The data stored may be output as tables. The table definition takes place in Room 3101 and is explained thoroughly in gINT documentation. In this section, several tables specifically prepared for the SSC project are introduced. The user may also define new tables more suitable to meet specific needs.

TABLE-1 Summary of Borings

This table summarizes boring definition data for the overall project or for a given range of borings, as shown in Figures 6 and 7. Figure 7 shows a table output after transfer to Lotus/123/Allways™ software. This transfer allows additional manipulations of data.

LAYER-1 Layer Data Summary

A volumninous list of lithologic layers with top and bottom depths; each layer is identified by the reserved word MATLDESC defined in Room 2204 and shown in Figure 5. Figures 8 and 9 show a list of layers for the full extent of the boring and a list of bentonite layers, respectively. The latter has been obtained through filtering the specific reserved work LYR.MTLC.

LAB-1 Laboratory Data Summary

This table may be used to present a laboratory summary of one boring (Figure 10) or to create a picture of the geomechanical properties of a specific stratigraphic unit with several borings data (Figure 11).

DISCON-1 Discontinuity Description Summary

The description of discontinuities with reserved words from Room 2214 is presented for a specific boring (Figure 12). The table shown in Figure 13 introduces only the shear discontinuities with large dip angles for a specific stratigraphic layer over several borings.

RQD-1 Rock Quality Summary

Rock quality data may also be presented for the full boring extent or for a specific stratigraphic layer, as shown as Figures 14 and 15.

BORING SUMMARY TABLE
West Interaction Regions

BORING NUMBER	TOTAL DEPTH (feet)	GROUND ELEVATION (feet)	NORTH COORDINATE (feet)	EAST COORDINATE (feet)
BIR11	265	670	239029	2175454
BIR12	300	668	239008	2175582
BIR13	304	670	238844	2175494
BIR14	303	668	239199	2175518
BIR21	313	665	238620	2175708
BIR22	261	658	238494	2175935
BIR23	241	660	238320	2175840
BIR31	295	618	232079	2178442
BIR32	226	619	231944	2178644
BIR33	204	616	231722	2178541
BIR41	226	619	231388	2178618
BIR42	204	620	231357	2178714
BIR43	320	623	231237	2178839
BIR44	315	619	231160	2178664
BIR45	312	616	231515	2178508

BORING SUMMARY TABLE

West Interaction Regions

BORING ID	TOTAL VERTICAL DEPTH (feet)	GROUND ELEVATION (feet)	NORTH COORDINATE (feet)	EAST COORDINATE (feet)
BIR11	265	670	239029	2175454
BIR12	300	668	239008	2175582
BIR13	304	670	238844	2175494
BIR14	303	668	239199	2175518
BIR21	313	665	238620	2175708
BIR22	261	658	238494	2175935
BIR23	241	660	238320	2175840
BIR31	295	618	232079	2178442
BIR32	226	619	231944	2178644
BIR33	204	616	231722	2178541
BIR41	226	619	231388	2178618
BIR42	204	620	231357	2178714
BIR43	320	623	231237	2178839
BIR44	315	619	231160	2178664
BIR45	312	616	231515	2178508

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TABLE-1
Example #2

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Figure 7

Layer Data Summary of Boring BIR82
Page 1

Top Depth (feet)	Bottom Depth (feet)	Layer Material Code (*)
0.00	1.60	CLML
1.60	21.60	CLML
21.60	40.00	WEAMARL
40.00	150.80	WEAMARL
150.80	151.40	LIMESTON
151.40	154.40	MARL
154.40	154.80	LIMESTON
154.80	155.00	MARL
155.00	160.20	LIMESHAL
160.20	160.80	SHALE
160.80	166.80	LIMESTON
166.80	167.60	LIMESHAL
167.60	182.20	LIMESTON
182.20	190.20	LIMESHAL
190.20	197.00	LIMESTON

(* Material codes defined in Room 2204)

Layer Data Summary of Boring BIR11

Bentonite and Bentonitic Shale Layers

Top Depth (feet)	Bottom Depth (feet)	Layer Material Code (*)
20.60	*21.00*	*BENS*
104.20	*104.60*	*BENT*
111.20	*112.00*	*BENS*
145.40	*146.20*	*BENT*
149.00	*150.20*	*BENT*
173.40	*173.80*	*BENS*
191.60	*192.00*	*BENS*

*(* Material codes defined in Room 2204)*

SUMMARY TABLE OF LABORATORY DATA
Boring BIR11

Boring Number	Sample Depth (ft)	Moist. Cont. (%)	Dry Dens. (pcf)	Atterberg Limits LL	Atterberg Limits PI	Carb. Cont. (%)	Uncon. QU (psi)	Triax. Sigma3 (psi)	Test Su (psi)	E50 (x10e5 psi)	Braz. Tens. (psi)
BIR11	3.7	13.5									
BIR11	4.3	13.8	119.7				2073				
BIR11	50.4	15.0									
BIR11	50.8	13.2	122.7				2392				
BIR11	52.3	15.5									146
BIR11	100.2										264
BIR11	100.4	14.6									
BIR11	102.0	15.4	118.1				2338				
BIR11	102.3	17.2									
BIR11	102.6	16.9	115.6					100	855		
BIR11	103.1	17.1	113.1					500	1390		
BIR11	103.2	17.1	112.1				1095			3.2	
BIR11	149.0	32.3									
BIR11	150.3	11.3									
BIR11	151.9										267
BIR11	152.5	13.0	122.7				2655				
BIR11	152.9	12.9									
BIR11	200.0	15.2									
BIR11	200.1	16.3	117.1				2474				
BIR11	200.4	16.3									256
BIR11	220.2	17.6	115.2								
BIR11	220.4	17.5									
BIR11	221.3	17.1									
BIR11	225.0	17.2									
BIR11	225.2	17.3									
BIR11	229.3	15.6	119.1			5.0	278				
BIR11	232.9	14.9	119.7					100	195	2.0	
BIR11	233.4	15.7	118.3					500	217		
BIR11	235.0	15.6									
BIR11	235.7	16.7	115.5			6.6					
BIR11	236.0	16.0	118.4				446				
BIR11	236.5	16.2									
BIR11	245.9	17.0									
BIR11	253.3	14.6	121.0					100	237	1.0	
BIR11	253.7	14.7	121.2					300	234	1.9	
BIR11	254.1	15.0	119.0					600	293		
BIR11	256.1	16.8	116.0								
BIR11	260.9	15.6									
BIR11	261.2	18.6									
BIR11	261.8	15.8	118.0					500	264		
BIR11	262.0					5.6					
BIR11	262.2	15.8									
BIR11	262.5	15.0	119.6					100	236	0.9	
BIR11	262.6	15.9									
BIR11	262.9	16.1									
BIR11	263.0	16.0									

SUMMARY TABLE OF LABORATORY DATA

Unconfined Compressive Strength Test results of Austin Chalk Layers

Interaction Regions West

Boring Number	Vertical Sample Depth (ft)	Moisture Content (%)	Dry Density (pcf)	Atterberg Limits LL	Atterberg Limits PI	Carbonate Content (%)	Unconfined Compressive Strength (Qu) (psi)	Triaxial Compression Test Confining Pressure (psi)	Triaxial Compression Test Shear Strength Su (psi)	Young's Modulus (E50) (x10E5) (psi)	Brazil Tensile Strength (psi)
BIR11	4.3	13.8	119.7				2073				
BIR21	5.2	14.0	123.6				1923				
BIR33	6.5	17.1	115.0				1610				
BIR42	11.4	15.2	118.5				1484			2.3	
BIR21	24.3	12.8	123.2				2569				
BIR31	24.5	11.4	124.6				3480				
BIR32	43.9	14.7	118.8				1602			2.9	
BIR21	46.3	15.0	118.0				2626				
BIR33	48.5	16.4	116.0				1150				
BIR12	50.7	13.9	121.8				1930			5.4	
BIR11	50.8	13.2	122.7				2392				
BIR42	76.0	13.8	119.7				2025			6.3	
BIR45	81.7	18.7	110.8				1924			9.8	
BIR11	102.0	15.4	118.1				2338				
BIR11	103.2	17.1	112.1				1095			3.2	
BIR22	104.9	11.7	126.4				2301			4.6	
BIR23	106.3	14.9	117.9				2231				
BIR45	111.9	12.0	126.8				3015			4.8	
BIR31	126.7	16.2	118.9				2200				
BIR45	131.5	16.0	116.0				1794			5.6	
BIR23	139.8	39.1	85.4				170				
BIR42	145.3	10.8	128.5				1941			4.5	
BIR12	149.0	11.7	125.8				927			3.2	
BIR45	151.1	14.4	120.2				2699			9.6	
BIR11	152.5	13.0	122.7				2655				
BIR21	152.8	14.9	119.1				2758				
BIR33	157.9	16.5	116.0				1790				
BIR11	200.1	16.3	117.1				2474				
BIR23	201.0	12.7	123.7				2007				

* *Increasing Depths of Samples*

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LAB-1
Example #2

DISCONTINUITIES DESCRIPTION SUMMARY
Boring BIR23

Boring Number	Disc. Depth (Ft)	Joint Bed. Shear	Dip (deg)	Separation	Type of Filling	Amount of filling None	Part.	Comp.	Disc. Surf. Cond.	Disc. Surf. Rough.
BIR23	27.50	B	0			X			S	
BIR23	30.40	B	0			X			S	
BIR23	32.70	B	0			X			S	
BIR23	36.50	B	0			X			S	
BIR23	42.60	B	0			X			S	
BIR23	49.00	B	0			X			S	
BIR23	53.70	B	0			X			S	
BIR23	56.50	B	0			X			S	
BIR23	59.20	B	0			X			S	
BIR23	63.90	B	0			X			S	
BIR23	67.80	B	0			X			S	
BIR23	73.50	B	0			X			S	
BIR23	76.60	B	0			X			S	
BIR23	83.30	B	0			X			S	
BIR23	87.30	B	0			X			S	
BIR23	95.30	B	0			X			S	
BIR23	99.80	B	0			X			S	
BIR23	102.40	B	0			X			S	
BIR23	105.30	B	0			X			S	
BIR23	109.10	B	0			X			S	
BIR23	113.10	B	0			X			S	
BIR23	124.70	B	0			X			S	
BIR23	126.90	B	0			X			S	
BIR23	130.70	B	0			X			S	
BIR23	133.40	B	0			X			S	
BIR23	135.60	B	0			X			S	
BIR23	137.00	B	0			X			S	
BIR23	139.40	B	0			X			S	
BIR23	139.60	J	60	C		X			S	S
BIR23	139.80	J	60	C		X			S	S
BIR23	155.10	B	0			X			S	
BIR23	172.40	J	45	C		X			S	S
BIR23	173.10	B	0			X			S	
BIR23	185.00	B	0			X			S	
BIR23	189.00	B	0			X			S	
BIR23	194.40	B	0			X			S	
BIR23	224.50	J	60	C		X			S	S

DISCONTINUITIES DESCRIPTION SUMMARY

Interaction Regions West

Steeply Deeping Shears In Austin Chalk Layers

Boring Number	Vertical Discontinuity Depth (Ft)	Discontinuity Type	Dip * (degree)	Separation	Type of Filling	Amount of Filling			Discontinuity Surface	
						None	Partial	Complete	Condition	Roughness
BIR22	194.80	S	90	T	Calcite		X		A	S
BIR31	133.70	S	80	C		X			S	S
BIR31	158.40	S	60	C		X			S	S
BIR31	148.30	S	60	C				X	S	S
BIR21	143.60	S	60	C		X			S	S
BIR12	142.00	S	55				X		S	R
BIR45	107.30	S	50	C		X			S	S
BIR22	103.70	S	50		Calcite		X		S	R
BIR11	143.50	S	50	C		X			S	R
BIR45	106.20	S	45	C	CALCITE			X	S	S
BIR31	150.00	S	45	C		X			S	S
BIR31	133.90	S	45	C		X			S	S
BIR21	177.60	S	45	C		X			S	S
BIR13	25.60	S	45	C		X			S	S
BIR11	143.10	S	45	C		X			S	R

** Decreasing Dip Values*

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DISCON-1
Example #2

5-90

Figure 13

RQD Depth Range Table
Boring BIR11

Boring Number	Range Data Top Depth (feet)	Range Data Bottom Depth (feet)	Range Data Core recovery (%)	Range Data RQD (%)
BIR11	3.0	5.0	96	96
BIR11	5.0	10.0	95	95
BIR11	10.0	15.0	100	100
BIR11	15.0	25.0	96	96
BIR11	25.0	35.0	98	98
BIR11	35.0	45.0	100	100
BIR11	45.0	55.0	100	100
BIR11	55.0	65.0	99	99
BIR11	65.0	75.0	95	95
BIR11	75.0	85.0	97	97
BIR11	85.0	95.0	98	98
BIR11	95.0	105.0	100	100
BIR11	105.0	115.0	100	100
BIR11	115.0	125.0	100	100
BIR11	125.0	135.0	100	100
BIR11	135.0	145.0	100	88
BIR11	145.0	155.0	100	100
BIR11	155.0	165.0	100	100
BIR11	165.0	175.0	100	100
BIR11	175.0	185.0	100	100
BIR11	185.0	195.0	100	100
BIR11	195.0	205.0	100	100
BIR11	205.0	215.0	100	100
BIR11	215.0	225.0	100	96
BIR11	225.0	235.0	95	95
BIR11	235.0	245.0	100	100
BIR11	245.0	255.0	100	100
BIR11	255.0	265.0	100	100

RQD Depth Range Table

Interaction Regions West

Boring Number	Range Data Top Depth (feet)	Range Data Bottom Depth (feet)	Range Data Recovery (%)	Range Data RQD * (%)
BIR33	*6.00*	*11.00*	*100*	*N/A*
BIR33	*4.00*	*6.00*	*45*	*N/A*
BIR33	*2.00*	*4.00*	*50*	*N/A*
BIR13	*158.00*	*168.00*	*89*	*89*
BIR32	*90.00*	*97.60*	*100*	*88*
BIR11	*135.00*	*145.00*	*100*	*88*
BIR13	*121.00*	*128.00*	*81*	*81*
BIR31	*112.00*	*122.00*	*80*	*80*
BIR23	*203.00*	*213.00*	*78*	*78*
BIR43	*171.00*	*179.00*	*73*	*73*
BIR22	*76.80*	*84.00*	*85*	*70*
BIR22	*20.10*	*27.10*	*100*	*70*
BIR43	*179.00*	*189.00*	*69*	*68*
BIR45	*151.00*	*161.00*	*67*	*67*
BIR31	*160.00*	*170.00*	*56*	*56*
BIR13	*81.00*	*91.00*	*54*	*54*
BIR13	*101.00*	*111.00*	*52*	*52*
BIR33	*21.00*	*31.00*	*55*	*50*
BIR31	*150.00*	*160.00*	*100*	*50*
BIR22	*192.70*	*200.10*	*60*	*43*
BIR13	*196.00*	*206.00*	*26*	*26*
BIR32	*21.20*	*28.90*	*15*	*10*
BIR12	*4.60*	*9.20*	*54*	*0*
BIR42	*10.40*	*10.80*		

Low RQD Depth Ranges (<90%) in Austin Chalk Layers

Decreasing RQD Values

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RQD-1
Example #2

5-90

Figure 15

ROOM 3203 - GRAPH OUTPUT

Graph plots are defined in Room 3103 (See gINT documentation). Graphs can supplement tables to enhance presentation of the data. As mentioned before, a large number of possibilities are available for specific needs.

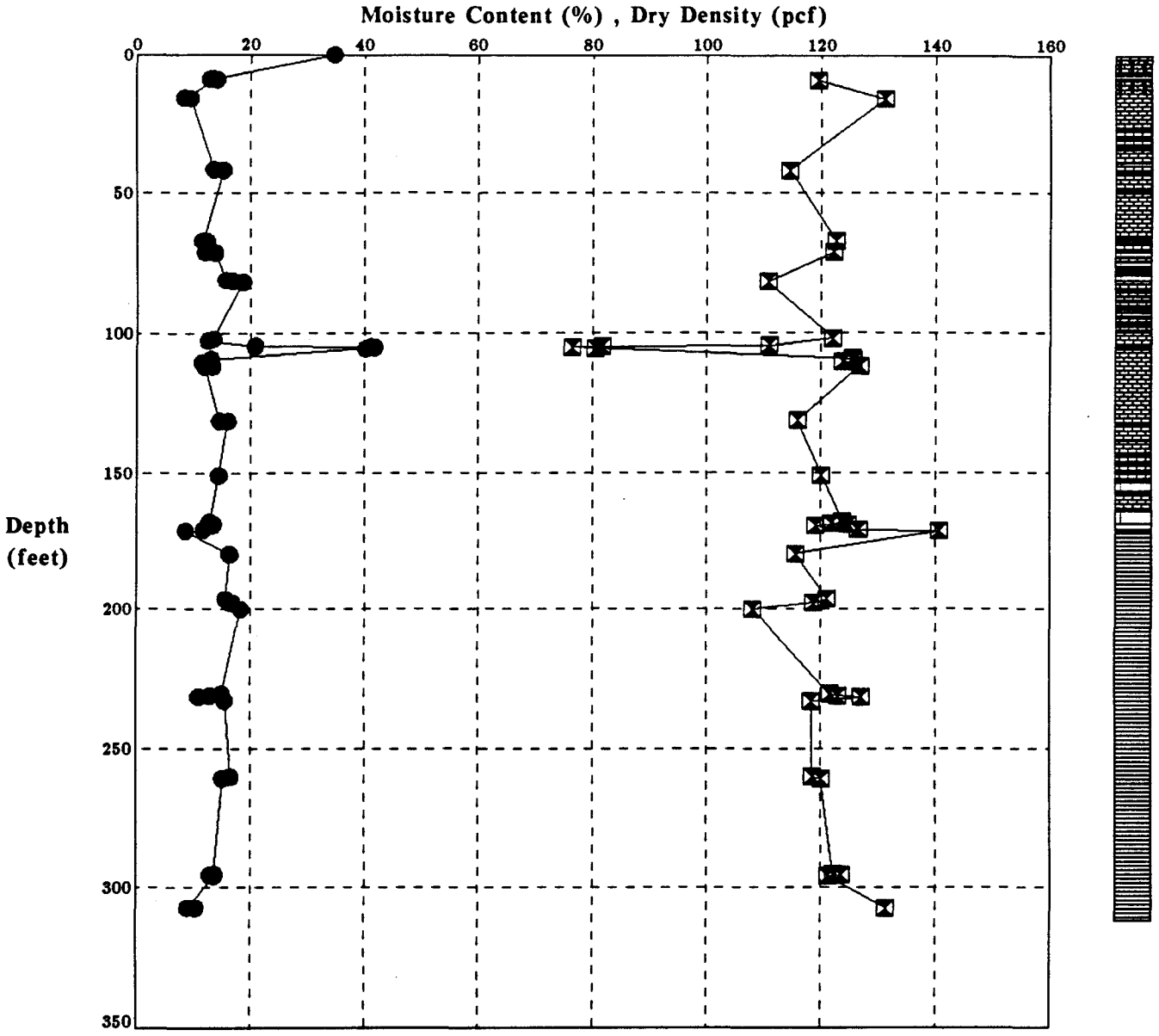
GRLAB-1 Moisture Content/Dry Density versus Depth

This graph also provides a lithologic column of the boring (Figure 16).

SITE-1 Large Scale Site Plan (Figure 17)

SITE-2 Small Scale Site Plan (Figure 18)

Boring BIR45



SSC Laboratory

● Moisture Content (%)

⊠ Dry density (pcf)

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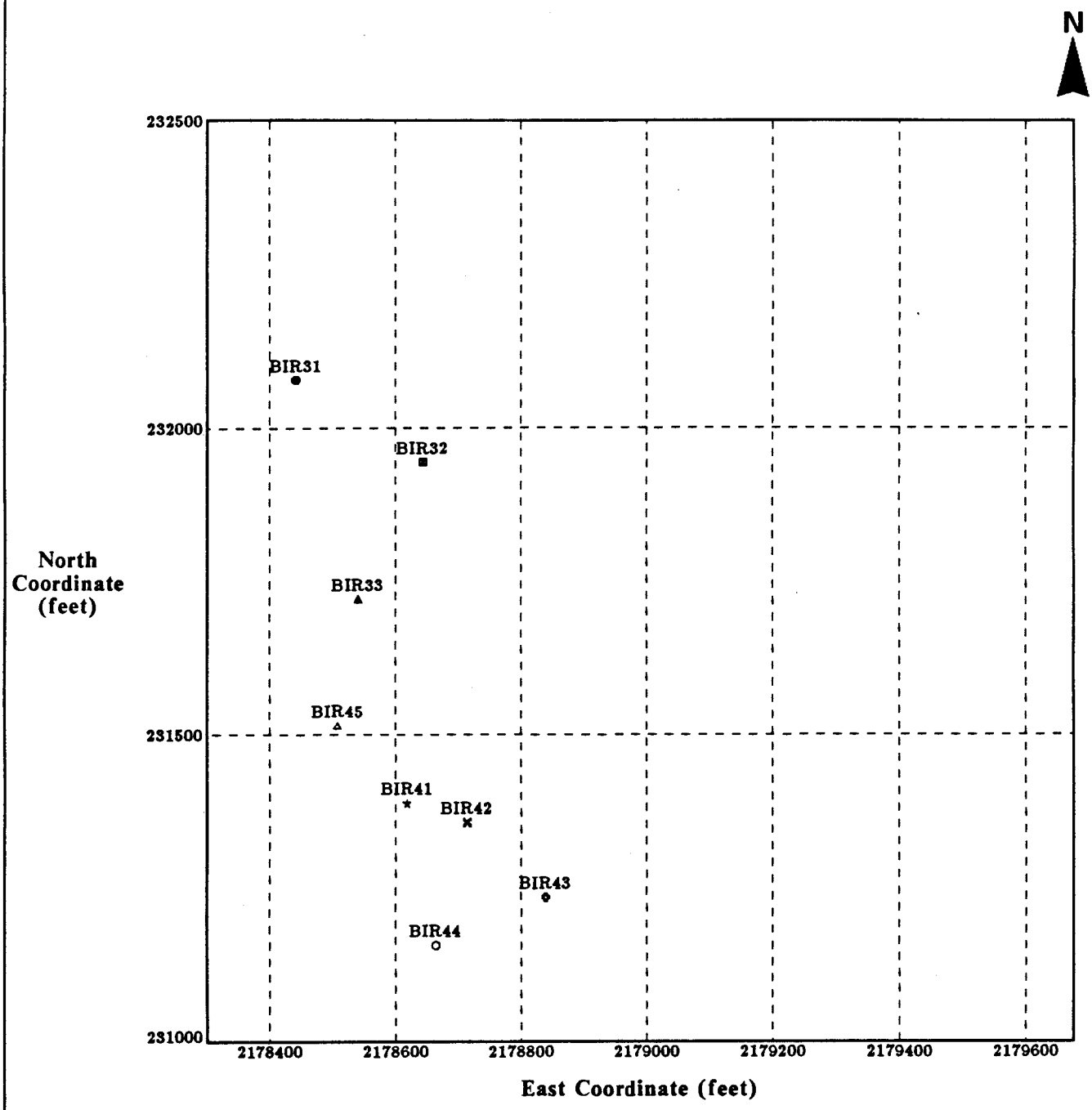
GRLAB-1
Example #1

5-90

Figure 16



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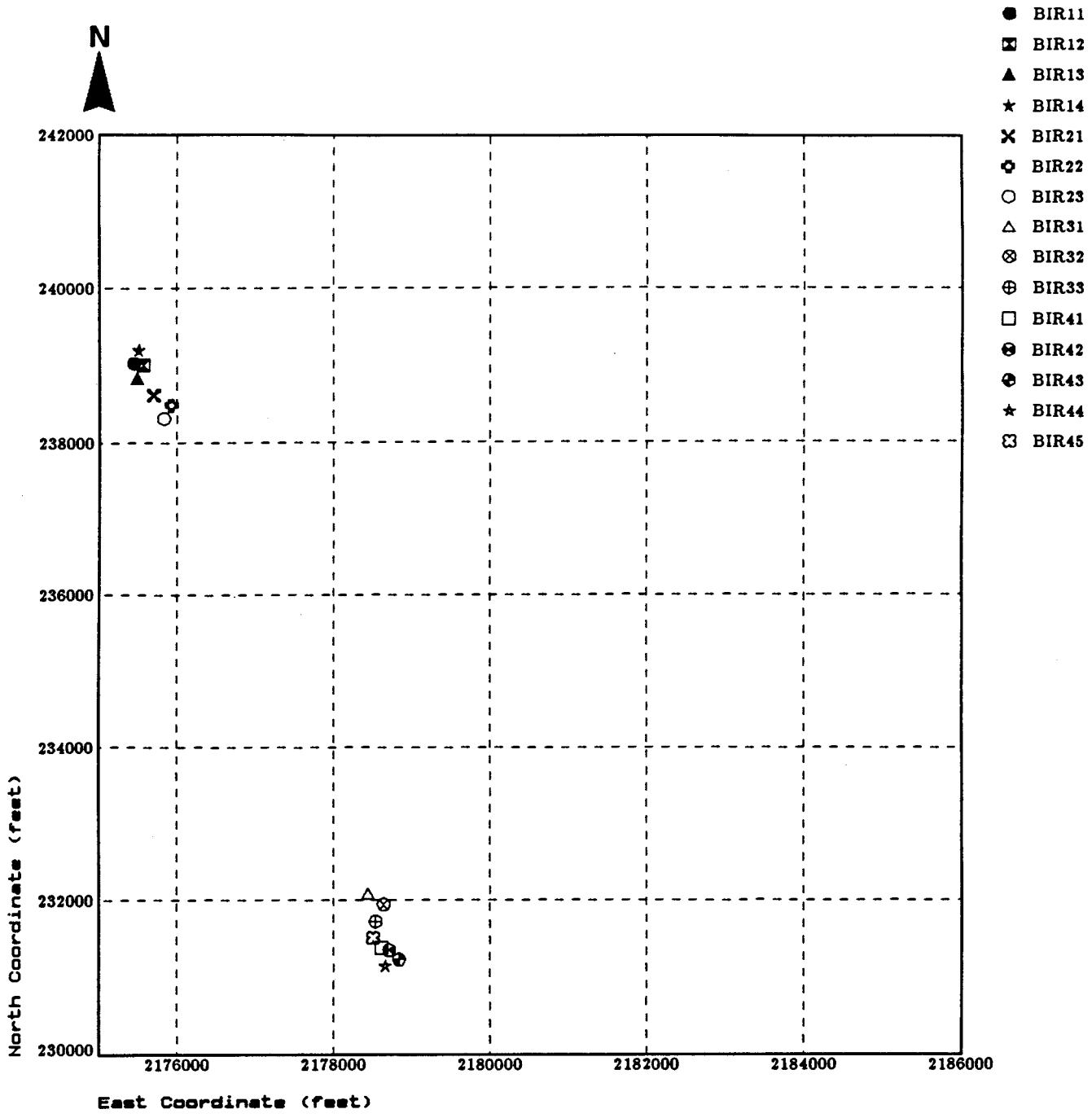
SITE-1
Example #1

5-90

Figure 17



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SITE-2
Example #1

5-90

Figure 18

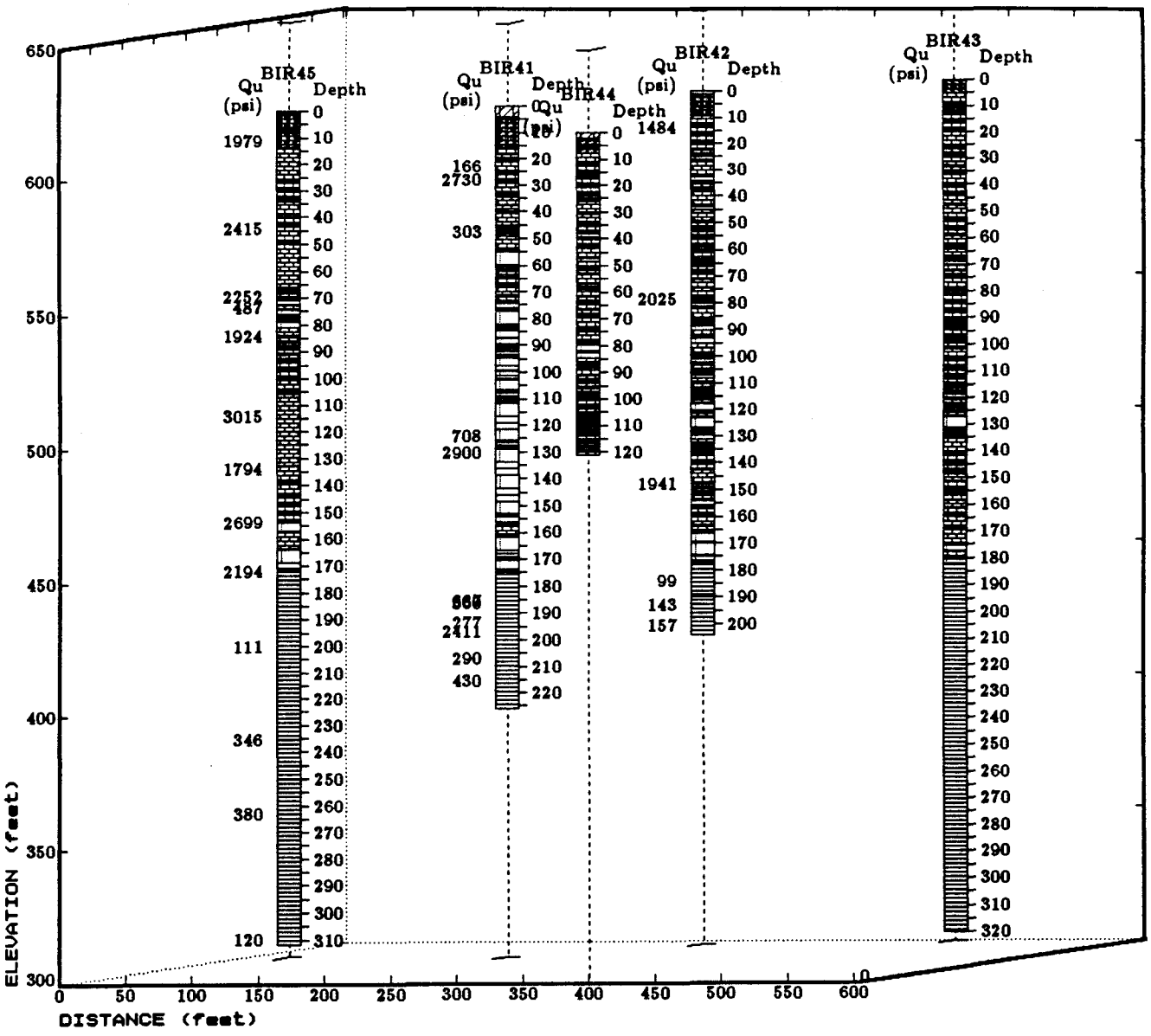
ROOM 3204 - BORING LOG OUTPUT

The boring log format is an 11-inch by 17-inch landscape sheet printed in two half pages (8-1/2-inch by 11-inch portrait) and assembled together (See Figure 1). Boring log pages are defined in Rooms 3104 and 3105, as explained in the gINT documentation.

The SSC project-specific boring log sheets have been named SSC3LAS1 for the left side and SSC4LAS2 for the right side.

ROOM 3206 - FENCE DIAGRAM OUTPUT

Three-dimensional diagrams are available through the SSCFENCE template, as shown on Figure 19. It is possible to define additional fence diagrams in Room 3106.



Boring	North	East	Elev.	Depth
BIR41	231388	2178618	619	226
BIR42	231357	2178714	620	204
BIR43	231237	2178839	623	320
BIR44	231160	2178664	619	315
BIR45	231515	2178508	616	312

Position	North	East
Left, Front	231459	2178398
Right, Front	231009	2178798
Left, Back	231580	2178534
Right, Back	231130	2178934

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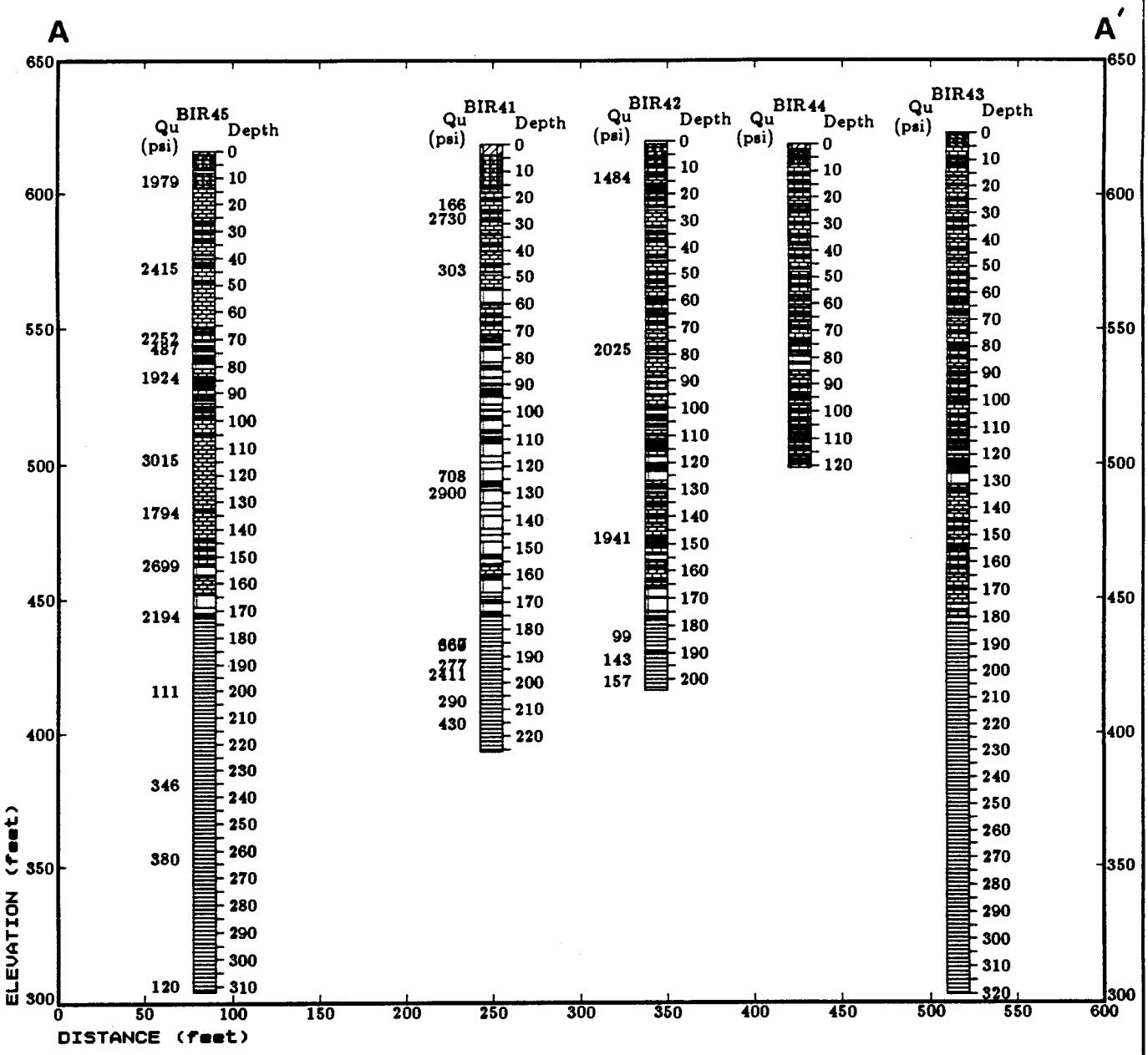
SSCFENCE
Example #1

5-90

Figure 19

ROOM 3207 - PROFILE OUTPUT

Two-dimensional profiles may be output with SSCPROFI template, as shown in Figure 20. However, specific needs may also be accommodated by defining new templates in Room 3106.



Boring	North	East	Elev.	Depth
BIR41	231388	2178618	619	226
BIR42	231357	2178714	620	204
BIR43	231237	2178839	623	320
BIR44	231160	2178664	619	315
BIR45	231515	2178508	616	312

BASE LINE

Point	North	East
A	231531	2178414
A'	231161	2178886

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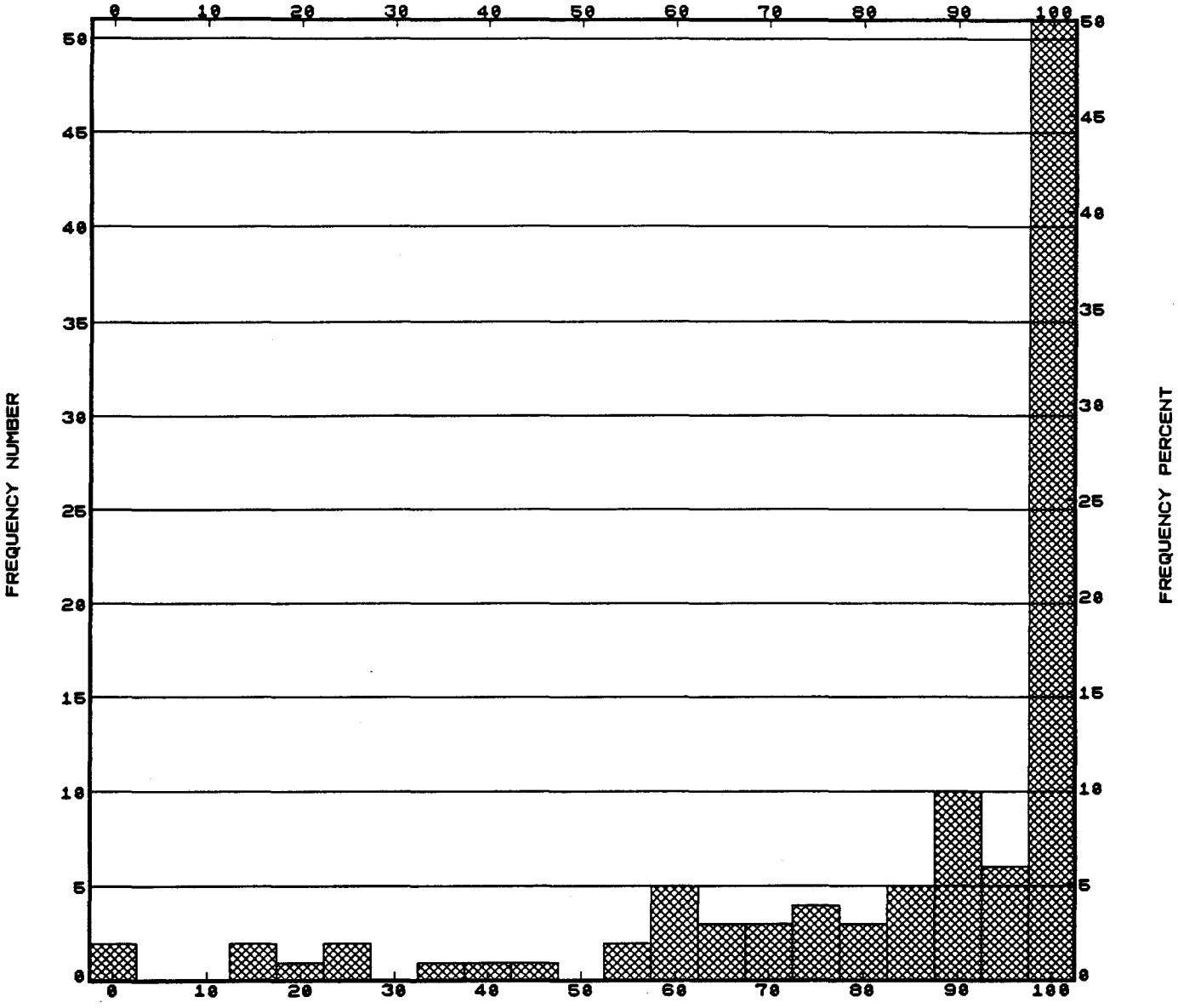
SSCPROFI
Example #1

5-90

Figure 20

ROOM 3208 - HISTOGRAM OUTPUT

Histograms, defined in Room 3108, provide a graphic aid to the presentation of data in tables. As a complement of table RQD-1, the following example (HISRQD-1, see Figure 21) may be useful.



SSC Laboratory	The Earth Technology Corporation	Project No. 87-888 SSC Data Base Manual
Western Interaction Regions. Eagle Ford Shale Layers.		HISRQD-1 Example #1
	5-90	Figure 21

REFERENCES

Classification of Subsurface Materials (Soil and Rock). Southwestern Laboratories. Superconducting Super Collider, Ellis County, Texas.

Earth Technology, 1990. Superconducting Super Collider, Site Reference Stratigraphic Column, Report to RTK, a Joint Venture.

gINT, The gEOTECHNICAL INTegrator, Version 3.1, Documentation. Salvatore Caronna, 1990.

Mason-Johnston & Associates, 1989. Laboratory Manual for SSC Geomechanical Testing, Internal Report.

Southwestern Laboratories, 1989. Laboratory Manual for SSC Geomechanical Testing, Internal Report.

Style of Faults and Associated Fractures in Austin Chalk, Northern Extension of the Balcones Fault Zone, Central Texas, Donald Reasor, Edward W. Collins, Vol. 38, 1988.

RESERVED WORDS LIST

This partial list of reserved words supplements the main list attached to the gINT manual and includes the reserved words used for the SSC project.

Reserved Word	Description
DEPTH	Specimens or sample depth
LOGNOTE2	Log notes II
LOGNOTE3	Log notes III
LOGNOTE4	Log notes IV
LOGNOTES	Log notes
LYR.BOPH	Log layers; Bottom depth of layer on logs
LYR.HELD	Log layers; Bottom elevation and depth of layer
LYR.BELL	Log layers; Bottom elevation of layer on logs
LYR.BOTD	Log layers; Bottom depth of layer
LYR.BOTE	Log layers; Bottom elevation of layer
LYR.CODE	Log layers; Layer code
LYR.MTLC	Log layers; Material symbol code
LYR.TOPD	Log layers; Top depth of layer
LYR.TOPE	Log layers; Top elevation of layer
MATLDESC	Log Material Description, only on tables for logs
MATLGRPC	Log Material graphics column
PG	Page number of output
PRJ.NUM	Project number
PT.BDTEL	Exploration point bottom elevation
PT.DEPTH	Exploration point depth
PT.DRILLR	Exploration point driller
PT.EAST	Exploration point east coordinate

RESERVED WORDS LIST continued

PT.ELEV	Exploration point surface elevation
PT.END1	Explor. point end date 7/6/89
PT.ID	Exploration point identification
PT.NORTH	Exploration point north coordinate
PT.STRT1	Explor. point start date 7/6/89
RDT.BOTD	Range Data bottom depth
RDT.LEN	Range Data length
RDT.TOPD	Range Data top depth
RDTPARM1	Range Data parameter 1
RDTPARM2	Range Data parameter 2
RJP.DIP	Rock Joints: Dip
RJP.FILL	Rock Joints: Filling
RJP.ORNT	Rock Joints: Orientation to dip
RJP.RUFF	Rock Joints: Roughness
RJP.SPAC	Rock Joints: Spacing
RJPCODE1	Rock Joints: CODE 1
RJPCODE2	Rock Joints: CODE 2
RJPCODE3	Rock Joints: CODE 3
RJPCODE4	Rock Joints: CODE 4
SMP.BDPH	Sample bottom depth
SMP.BOTD	Sample bottom depth
SMP.DSC1	Sample description code 1
SMP.LEN	Sample length
SMP.TOPD	Sample top depth

RESERVED WORDS LIST continued

SPACE	Empty columns in tables
WELL	Log well graphics column
WLL.BDPH	Well log; Section bottom depth
WLL.DESC1	Well log; Section description code 1
WLL.DESC2	Well log; Section description code 2
WLL.DESC3	Well log; Section description code 3
WLL.DESC4	Well log; Section description code 4
WLL.SECT	Well log; Section type code
$CC	Carbonate content
$DATA1	Shear strength during triaxial compression
$DATA2	Confining pressure during triaxial compression
$DD	Dry density
$LL	Liquid limit
$MC	Moisture
$MODULUS	Tangent Young's modulus
$PI	Plasticity index
$QU	Unconfined compressive strength
$TENSILE	Brazil tensile strength

APPENDIX A

EARTH TECHNOLOGY CORING PROCEDURE (F-3-1)

LIST OF EFFECTIVE PAGES

Page No.	Effective Date
1 thru 21	9/1/86
(Appendix) A-1 thru A-3	9/1/86
	9/1/86

Form No.	Effective Date
F-3-1-1A	9/1/86
F-3-1-1B	9/1/86

APPROVED BY:

G. Ramanjaneya 9/9/86

G. RAMANJANEYA DATE

DIRECTOR OF TECHNICAL RESOURCES

Alain Sharp 9/9/86

ALAIN SHARP DATE

QUALITY ASSURANCE MANAGER

Bruce A. Schell 9-10-86

BRUCE SCHELL DATE

PEER REVIEW COMMITTEE CHAIRMAN

CORE LOGGING
PROCEDURE F-3-1

1.0 Purpose

This procedure provides guidelines for lithologic and geotechnical descriptions of rock cores.

2.0 Scope

This procedure establishes generalized requirements for the logging of rock cores. It does not provide guidelines for logging of soils or unconsolidated sediments. The items covered in this procedure are:

2.1 Planning (6.1)
2.2 Procedures (6.2)
2.3 Check and Approval (6.3)

3.0 Definitions

3.1 Rock quality designation (RQD): a core-recovery parameter in which the lengths of all the pieces of intact core greater than twice the diameter are summed and then divided by the total length drilled. RQD is generally expressed as a percentage.

3.2 Technical Representative (Tech. Rep.): The Earth Technology Corporation geologist, engineer or technician assigned to log the core.

3.3 Total core recovery: the summed length of all pieces of recovered core from a cored interval divided by the length drilled and expressed as a percentage.

4.0 References

4.1 Shuri, Frank S., Michael L. Feves, Gary L. Peterson, Kevin M. Foster and Clive F. Kienle, Jr., 1981. Field and In Situ Rock Mechanics Testing Manual, Foundation Sciences, Inc., ONWI-310.

4.2 Brown, E.T. (ed), 1981. "Rock Characterization Testing and Monitoring - ISRM Suggested Methods," Commission on Testing Methods, International Society for Rock Mechanics, pp. 42-52.

4.3 ASCE Task Committee for Foundation Design Manual, 1972. Surface Investigation for Design and Construction of Foundations of Buildings: Part II, Proc. Am. Soc. Civ. Eng., J. Soil Mech. Fnds. Div., SM6.

4.4 Core Logging Committee of the South Africa Section of the Association of Engineering Geologists, 1976. "A Guide to Core Logging for Rock Engineering," Proceedings of the Symposium on Exploration for Rock Engineering, pp. 71-94.

5.0 Equipment

5.1 Measuring tape at least 3 m (10 ft) long, graduated to at least 2.5 mm (0.1 in) shall be used for measuring length along rock cores.

5.2 Hand lens of approximately 10 power magnification for examining rock materials.

5.3 Log forms (F-3-1-1A & B).

5.4 Geologist's rock hammer

5.5 Pocket knife to determine hardness.

5.6 Hydrochloric acid (5% solution) to indicate the presence of carbonate in rock cores.

5.7 V trough as required by project needs to hold retrieved cores during core logging.

5.8 Equipment such as, engineer's scale, straight edge, protractor, clipboard, indelible markers, as required to efficiently log and label the core and perform the field characterization tests.

5.9 Camera, scale, and appropriate identification label or board to show sample number, depths, date, etc., if core phohographs are to be taken.

6.0 Procedures

6.1 Planning

The Project Manager or his designated representative shall issue a Specific Work Instruction (SWI) per procedure QA-2-3 for sample logging. The SWI shall include:

6.1.1 Summary Project Description.

6.1.2 Personnel responsible for logging the core.

6.1.3 Personnel responsible for checking and approving the work.

6.1.4 Schedule.

6.1.5 Data requirements on the logging form.

6.1.6 Additional information as required to perform the work.

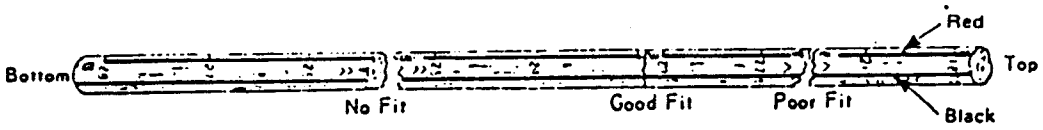
These instructions may be included in the SWI issued for Rock Core Drilling Procedure F-3.

6.2 Logging

6.2.1 Carefully remove all core pieces from the core barrel. Clean the core with a cloth and wipe dry.

6.2.2 Assemble the core pieces in the V trough by fitting their ends together. When the core from the entire run is aligned, scribe the core with two reference lines using indelible black and red felt marker pens and a straight edge

(the core must be relatively dry to prevent smudging). The lines shall be scribed side by side, parallel to the core axis with black lines to the right and red lines to the left when the core logger is looking toward the top of the core as illustrated below. Mark the depth footage on each core piece, if required by Activity Plan or SWI.



6.2.3 Document the required information in core log form (F-3-1-1A and B). Unless otherwise specified in the SWI (Sec. 6.1).

- o Client - The name of the client.
- o Project Name - The name of the project.
- o Project Number - The Earth Technology project number
- o Coordinates - The location of the top of the borehole in latitude and longitude or township/range designation, if available
- o Hole Number - The designated borehole number.
- o Elevation - The elevation of the borehole, if known.
- o Orientation - The inclination of the boreholes in degrees from horizontal and the bearing in degrees clockwise from north (azimuth) if required by the project.
- o Depth - The maximum depth of the borehole.

- o Date Started - The date when drilling was started.
- o Date Finished - The date when drilling was completed.
- o Water Table - If required by written instructions, the depth of the water table in the borehole measured to ± 0.1 ft (0.03 m) and the date of the reading.
- o Core Boxes - The designation of the core boxes used to hold the cores from the borehole.
- o Date - The date the core was logged.
- o Logging Personnel - The individual(s) logging the core.
- o Page Numbers - The first log form for each borehole shall be page 1 (Form F-3-1-1A). Additional log forms are numbered sequentially for each corehole (Form F-3-1-1B). The total number of pages is entered after logging of all cores from the borehole is complete.
- o Drilling Rig/ Driller - Type of machine used for drilling and driller's initials.
- o Drilling Methods & Fluid - Type of drilling method and drilling fluid used.
- o Core Barrel & Bit Data - Type and diameter of core barrel(s) and bit(s) used shall be entered.
- o Plus any additional information specified in the SWI (Section 6.1.5)

6.2.4 Core Quality Description and Logging

Elevation and Depth - The elevation of the borehole above mean sea level, if known, and its total depth below the ground surface shall be entered. Elevations and depths shall be recorded on the log where major formational or structural changes occur.

Core Loss Log - Sections of the borehole from which core was successfully recovered are represented by a solid bar in the core loss column. Intervals of core loss (CL) when identifiable are left open and labeled "CL". Otherwise an interval of the appropriate length is left open at the end of each run and labeled "CL-UN" (core loss-unknown depth).

Total Core Recovery - Total Core Recovery for each cored interval shall be entered in the appropriate columns.

Rock Quality Designation (RQD) - The rock quality designation (RQD) is a percentage of core recovered and calculated as the sum of all pieces of intact core greater than twice the diameter, divided by the total length drilled. Pieces shorter than twice the diameter resulting from closer jointing, faulting, or weathering should not be summed. If the core is broken by handling or by the drilling process (i.e., if the fractures clearly are fresh breaks rather than natural discontinuities), the freshly broken pieces shall be fitted together and considered as one piece. The RQD values of individual beds, structural domains, weakness zones, etc., shall be logged separately to indicate any inherent variability and to provide a more accurate picture of the location and width of zones with small RQD value.

Fracture Log - Fractures shall be recorded graphically at the depths and orientations where they occur. Breaks which are clearly a result of drilling or handling (as opposed to natural breaks such as joints) shall be shown with a jagged line and labeled as "MB" (mechanical break). The orientation shall be related to the black core scribe line (Section 6.2.2).

Structural Description - The joints, beds, foliation, shears or gouge zones, etc., shall be described. In general, the size of the feature, geometry, and gouge or coatings or slickensides should be noted, as appropriate. In addition, characteristic discontinuities should be described as to orientation, spacing (Table 1), surface roughness (Table 2), fracture filling material (Table 3), separation and wall strength (Table 4), as listed below.

- o Orientation - Fracture planes are described in terms of azimuth and dip. Azimuth is the bearing of the plane projected to a horizontal ordinate scale of 0 to 360°. The strike direction to be recorded is the strike direction relative to the black scribe line if oriented cores are not available. Dip is the angle of the plane relative to horizontal measured normal to the azimuth.
- o Spacing - The spacing between discontinuities is measured along the scribe line between adjacent natural discontinuities of one set (discontinuities with similar orientation). Standard terms for describing spacing are listed in Table 1.
- o Roughness - Roughness is described qualitatively of the fracture surface. The descriptive terms of Table 2 will be used for discontinuity classification.
- o Fracture-Filling Material - All materials occurring between the fracture walls are referred to as fracture filling. Fracture filling includes materials deposited or intruded between the fracture surfaces. The descriptions of fracture-filling material abundance shall use the terms given in Table 3. The filling material (i.e., bentonite, montmorillonite, etc.), stain, or coloration shall be described.

Table 1
Terms for Describing
Spacing of Rock Structures
(after ASCE, 1972)

Spacing	Joint	Bedding and Foliation
Less than 2 in (<50 mm)	Very Close	Very thin
2 in to 1 ft (50 mm to 30 cm)	Close	Thin
1 ft to 3 ft (30 cm to 1 m)	Moderately close	Medium
3 ft to 10 ft (1 m to 3 m)	Wide	Thick
More than 10 ft (<3 m)	Very Wide	Very thick

Table 2

Terms for Describing Roughness

(After CLC of S. Africa Section, 1976)

Classification	Description
Smooth	Appears smooth and is essentially smooth to the touch. May be slickensided.
Slightly Rough	Asperities (undulations) on the fracture surfaces are visible and can be distinctly felt.
Medium Rough	Asperities are clearly visible and fracture surface feels abrasive.
Rough	Large angular asperities can be seen. Some ridges and high angle steps evident.
Very Rough	Near vertical steps and ridges occur on the fracture surface

Table 3

Terms for Abundance of Fracture Filling Materials

(After CLC of S. Africa Section, 1976)

Description	Definition
Clean	No fracture filling material.
Stained	Coloration of rock only. No recognizable filling material.
Filled	Fracture filled with recognizable filling material.

Table 4

Terms for Separation of Fracture Walls

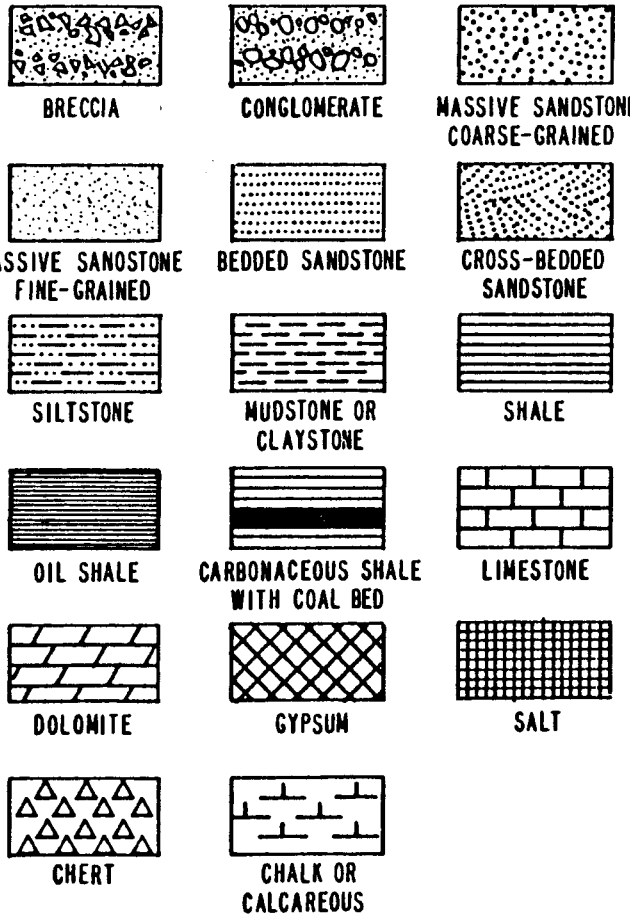
(After CLC of S. Africa Section, 1976)

Description	Separation of Wall (mm)
Closed	0
Very narrow	0 - 0. 1
Narrow	>0.1 - 1.0
Wide	>1.0 - 5.0
Very wide	>5.0

- Separation - Separation is the distance between fracture walls. If the separation is measurable, the terms in Table 4 shall be used.
- Wall Strength - Wall strength can be assessed either by Schmidt hammer testing of rigidly clamped core pieces or point-load testing across the core diameter. This is optional data and shall be performed as required by the project.
- Lithic Symbol - The lithic symbol is a graphic representation of the rock type. The symbols to be used are shown in Figure 1. Symbols for rock types not shown in Figure 1 may be specified by written instructions (SWI), as required by the project.
- Lithic Description - A standard macroscopic petrologic description of the rock shall be recorded for each rock type encountered. Variation of materials within a formation shall be noted at the appropriate depth (Form F-3-1-1A and B). The description shall include, as a minimum, the following information for each rock type encountered.
    - Rock type
    - Depth interval
    - Mineral composition
    - Color
    - Texture
    - Hardness
    - Weathering
    - Abundance and type of fossils
    - Any unusual or pertinent aspects (voids, inclusions, etc.).

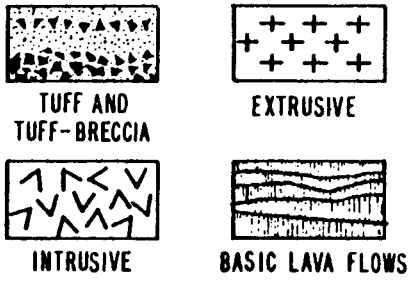
  Rock Type and Depth Interval - Rock type will be identified and recorded using the classification system given in Appendix A. Mineralogic composition and the estimated

SEDIMENTARY ROCKS



METAMORPHIC ROCKS

IGNEOUS ROCKS



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Field Procedure F-3-1

Standard Lithic Symbols

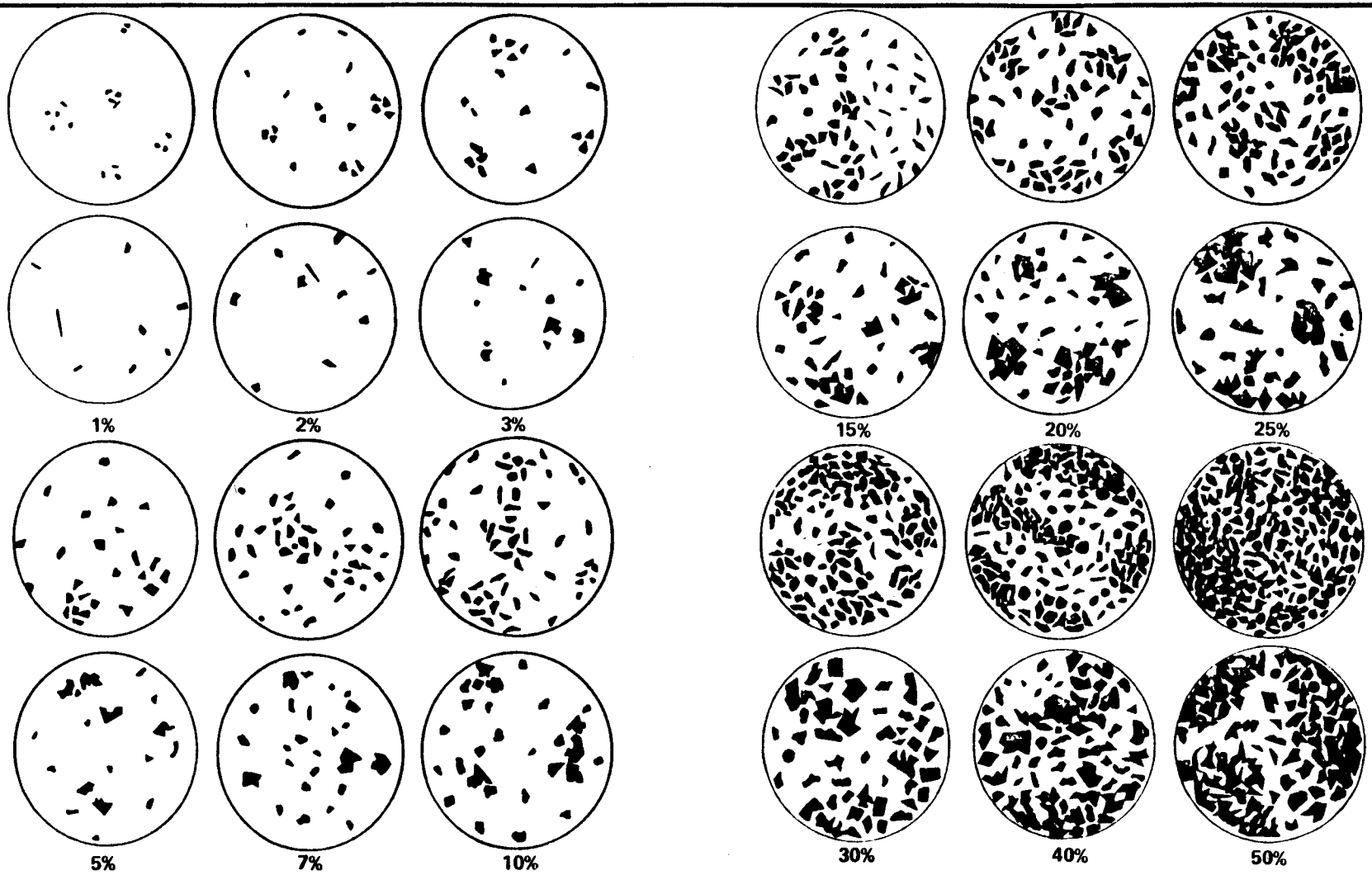
Figure 1

mineral percentages shall be recorded along with applicable color, textural information, and approximate percentages of important components (Figure 2).

Color - Colors are to be included in the description, with the use of the Munsell Color Chart recommended where pertinent. In many rock types, rock texture may give rise to an ill-defined or variable color. In these cases, the color of dominant minerals or the overall ground mass shall be described and the abundant colors of secondary minerals should be described separately.

Description of the rock texture, voids inclusions, etc. - Texture is a function of the size, shape, and arrangement of the grains or crystals of a rock. The most noticeable textural feature is grain/crystal size. The grain-size classification given on Table 5 which is based on visual identification shall be used. A grain/crystal size range and mode (most abundant size) should be given for the very coarse-grained rocks. For sedimentary rocks, roundness and sphericity are important textural parameters; roundness refers to the sharpness and angularity of corners of grains and fragments as shown in Figure 3. Sphericity refers to the degree the grains approximate a sphere as illustrated in Figure 3. For igneous and metamorphic rock, crystal face relationships are described according to the classifications shown on Table 5. Additional textural information shall include nature and filling of voids and grain interstices and specifics on rock fabric (i.e., porphyritic or glassy for igneous rock) as required for the project.

Hardness - Hardness shall be described as detailed on Table 6. Hardness shall indicate the overall rock condition and not that of individual minerals.



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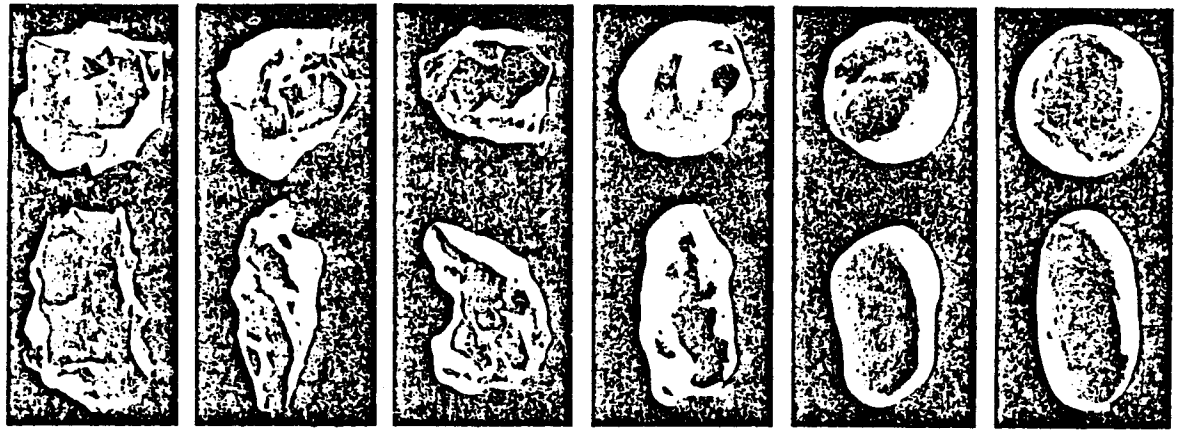
Field Procedure
F-3-1

Charts for Estimating Percentage Composition of Rocks and Sediments

Figure 2

DEGREES OF ROUNDNESS



(After Powers, 1955)

The Earth Technology Corporation	Field Procedure F-3-1
Roundness and Sphericity	
Figure 3	

Table 5

Grain Size Classification

Description	Size (mm)	Recognition	Equivalent Soil Type
Sedimentary Rock			
Very fine grained	<0.06	Individual grains/crystals cannot be seen with a hand lens	Clays & Silt
Fine grained	0.06 - 0.2	Just visible as individual grains/crystals under hand lens	Fine sand
Medium grained	0.2 - 0.6	Grains/crystals clearly visible under hand lens, just visible to the naked eye	Medium sand
Coarse grained	0.6 - 2.0	Grains/crystals clearly visible to naked eye	Coarse sand
Very coarse grained	>2.0	Grains/crystals measureable	Gravel
Igneous and Metamorphic Rock			**Rock Description**
Fine grained	<1.0	Grains difficult to recognize without hand lens	Aphanitic
Medium grained	1.0 - 5.0	Observable without hand lens	Phaneritic
Coarse grained	>5.0	Easily distinguished	Phaneritic

Table 6

Engineering Hardness Classification for Description of Rock
(after ASCE, 1972)

Designation	Description
VH	Very Hard - Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows from a hammer or geologist's pick.
H	Hard - Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
MH	Moderately Hard - Can be scratched with knife or pick. Gouges or grooves to 6.4 mm (1/4 in) deep can be excavated by hard blow of point of geologist's pick. Hand specimens can be detached by moderate blow.
M	Medium - Can be grooved or gouged 1.6 mm (1/16 in) deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 25 mm (1 in) maximum size by hard blows of the point of geologist's pick.
S	Soft - Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size (50 to 75 mm) by moderate blows of pick point. Small, thin pieces can be broken by finger pressure.
VS	Very soft - Can be carved with knife. Can be excavated readily with point of pick. Pieces of 25 mm (1 in) or more in thickness can be broken by finger pressure. Can be scratched readily by fingernail.

Weathering - The degree of weathering of the rock shall be described according to the classifications in Table 7. The interval over which the description applies shall be indicated by arrows in the weathering description column.

- o Tests and Remarks - The logger shall enter any remarks concerning unusual or noteworthy conditions such as loss of drilling fluids or large voids and note any test intervals, such as packer or point load tests. The photograph roll and photograph numbers may be entered in this column.

6.3 Photography

If required by the SWI (Sec 6.1) color print photographs or slides of the core and specific features may be required to support observations made during logging. If required by a SWI or Activity Plan, each photograph should contain:

- o borehole or corehole identification number
- o a graphic scale
- o top of core noted
- o project and name and number
- o footage (depth)

6.4 Check and Approval

6.4.1 The completed core log form shall be checked and signed by assigned personnel according to procedure QA-5.

6.4.2 The log shall be reviewed and approved by assigned personnel according to procedure QA-5.

Table 7

Rock Weathering Descriptions

(Shuri et al, 1981)

Designation	Description
I	Fresh: no visible sign of weathering
II	Faintly weathered: weathering limited to the surface of major discontinuities
III	Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material
IV	Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable
V	Highly weathered: weathering extends throughout rock mass and the rock material is partly friable
VI	Completely weathered: rock is wholly decomposed and in a friable condition but the rock texture and structure are preserved
VII	Residual soil: a soil material with the original texture, structure, and mineralogy of the rock completely destroyed

7.0 Records

7.1 SWI

7.2 Rock Core Log Data Sheet (F-3-1-1)

7.3 Approval cover sheets (Form QA-5-1)

7.4 Photographs

The Earth Technology Corporation

ROCK CORE LOG

Client	Project	Project No.
Hole Location	Hole No.	Elevation
Hole Angle	Bearing	Depth
Started	Finished	Core Boxes No. of
Depth Water Table	On (Date)	Logged By / Date
Drill Rig/Driller	Drilling Methods & Fluid	Core Barrel/Bit Data
Checked by	Date	Page No. of

Elevation	Depth	Core Loss Log	Total Core Recovery	R. Q. D.	Fracture Log	Structural Description	Lithic Symbol	Lithic Description	Weathering	Tests and Remarks

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ROCK CORE LOG

Client	Project	Project No.
Hole Location	Hole No.	Elevation
Checked by	Date	Page No.

Elevation	Depth	Core Loss Log	Total Core Recovery	R. Q. D.	Fracture Log	Structural Description	Lithic Symbol	Lithic Description	Weathering	Tests and Remarks

APPENDIX A
(Page 1 of 3)

CLASSIFICATION OF SEDIMENTARY ROCKS
By Russell B. Travis

TEXTURE →	GRAIN SIZE <1/256 mm.		GRAIN SIZE 1/256-2 mm.								GRAIN SIZE >2 mm.	
	CRYSTALLINE, CLASTIC OR AMORPHOUS		CRYSTALLINE, CLASTIC, BIOCLASTIC, OOLITIC, ETC.		CLASTIC UNCONSOLIDATED - silt, sand; CONSOLIDATED - siltstone, sandstone SIZE GRADES (mm) 1/256 - 1/16, silt; 1/16 - 1/8 very fine sand; 1/8 - 1/4, fine sand; 1/4 - 1/2, medium sand; 1/2 - 1, coarse sand; 1-2, very coarse sand						CLASTIC UNCONSOLIDATED - gravel (rounded), rubble (angular) CONSOLIDATED - conglomerate (rounded), breccia (angular) SIZE GRADES (mm) - 2-4, granules; 4-64, pebbles; 64-256 cobbles; >256 boulders	
COMPOSITION OF MAJOR FRACTION →	Composition as Indicated in left column (prefix appropriate names for mixtures)	Clay Minerals or Clay-Size Material	Composition as Indicated in left column (prefix appropriate names for mixtures)	Chiefly Calcite or Dolomite	Chiefly Quartz: >90% Quartz	Chiefly Quartz: Feldspar 10-25%	Chiefly Quartz: Rock Chips >10%	Quartz and >25% Feldspar	Quartz, Feldspar, Rock Chips, Pelitic Matrix, Angular grains, Tough.	Volcanic Ejecta	CHIEFLY ONE CONSTITUENT Especially quartz, chert, or quartzite. Also shale or limestone. Homogeneous conglomerates and breccias.	SEVERAL CONSTITUENTS Usually including unstable constituents. Mixed conglomerates and breccias.
COMPOSITION OF MINOR FRACTION: <10% Minor Fraction				LIMESTONE DOLOMITE ETC. All varieties in the Calcite-Dolomite horizontal column are possible here	QUARTZ SANDSTONE (Quartzose sandstone)	FELDSPATHIC SANDSTONE	LITHIC SANDSTONE	ARKOSE (Arkosic sandstone) Normally pink, red or light gray	GRAYWACKE—normally greenish gray SUBGRAYWACKE—low in feldspar, rock chips, or less angular grains. Tendency to chemical cement	ASH—unconsolidated fragments under 4 mm TUFF—consolidated ash VOLCANIC BRECCIA—angular fragments over 4 mm AGGLOMERATE—large proportion (>25%) of bombs These rocks are classified on the proportions of vitric, crystal (mineral), or lithic material they contain, for example "vitric lithic ash," or "crystal vitric tuff." If the mineralogy of the crystal or lithic fragments can be determined, the name of the appropriate volcanic rock can be prefixed as, "rhyolite vitric crystal tuff," or simply, "rhyolite tuff."	Name consists of chief constituent and size grade, for example: QUARTZ PEBBLE CONGLOMERATE CHERT COBBLE CONGLOMERATE LIMESTONE PEBBLE BRECCIA ETC.	Name consists of "mixed" or "polycomponent" and size grade, for example MIXED PEBBLE CONGLOMERATE or MIXED COBBLE CONGLOMERATE Name may include composition as GRAYWACKE ANDESITE CHERT PEBBLE CONGLOMERATE
Clay Minerals or Clay-Size Materials	CLAYSTONE—massive, blocky structure MUDSTONE—indurated mud. Includes claystone and siltstone SHALE—finely fissile. May include much silt CLAY SHALE (Argillaceous shale)—chiefly clay minerals ARGILLITE—highly indurated. Incipiently recrystallized BENTONITE—swells and disaggregates in water			ARGILLACEOUS LIMESTONE ETC. All varieties in the Calcite-Dolomite horizontal column are possible here	ARGILLACEOUS QUARTZ SANDSTONE	ARGILLACEOUS FELDSPATHIC SANDSTONE LOESS—fine sand or silt. Massive, porous, coherent	ARGILLACEOUS LITHIC SANDSTONE	ARGILLACEOUS ARKOSE	ARGILLACEOUS GRAYWACKE ARGILLACEOUS SUBGRAYWACKE		ARGILLACEOUS (rock grade) CONGLOMERATE [illegible]	ARGILLACEOUS MIXED (grade) CONGLOMERATE GLACIAL TILL—chaotic mixture of clay, sand and gravel TILLITE—indurated till FANGLOMERATE—alluvial fan material
SILICA: Opal, Chalcedony, Quartz	CHERT—chalcedony or opal. Bedded, nodular, massive DIATOMITE (Diatomaceous earth)—diatom tests RADIOLARITE (Tripoli, in part)—radiolarian tests SILICEOUS SINTER (Geyserite)—porous geyser deposit PORCELLANITE—argillaceous or silty chert	SILICEOUS SHALE — CLAYSTONE — MUDSTONE ETC.	SILICEOUS OOLITE—>50% oolitic OOLITIC CHERT—<50% oolitic DIATOMITE—diatom tests RADIOLARITE—radiolarian tests	SILICEOUS LIMESTONE—disseminated silica CHERTY LIMESTONE—containing chert nodules ETC. All varieties in the Calcite-Dolomite horizontal column are possible here	ORTHOQUARTZITE (Sedimentary quartzite) (Siliceous quartz sandstone)	FELDSPATHIC ORTHOQUARTZITE (Siliceous feldspathic sandstone)	LITHIC ORTHOQUARTZITE (Siliceous lithic sandstone)	SILICEOUS ARKOSE (Quartzitic arkose)	SILICEOUS SUBGRAYWACKE		SILICEOUS (rock grade) CONGLOMERATE (Orthoquartzitic (rock grade) conglomerate)	SILICEOUS MIXED (grade) CONGLOMERATE
CALCITE OR DOLOMITE	LIMESTONE—chiefly calcite, massive DOLOMITE (Dolostone)—chiefly dolomite, massive CHALK—chalky texture TUFA—very porous, friable TRAVERTINE—banded, coherent, denser than tufa CALICHE—lime-rich deposit formed near surface	CALCAREOUS SHALE (Limy shale) etc. MARLSTONE 25-75% carbonate	LIMESTONE — chiefly calcite, crystalline DOLOMITE (Dolostone) — chiefly dolomite, crystalline CLASTIC LIMESTONE (Calcarenite or calcite sandstone) — clastic CALCAREOUS OOLITE — >50% oolitic OOLITIC LIMESTONE — <50% oolitic COQUINA — shells, little cement ORGANIC LIMESTONE — reefy, fossiliferous		CALCAREOUS QUARTZ SANDSTONE	CALCAREOUS FELDSPATHIC SANDSTONE	CALCAREOUS LITHIC SANDSTONE	CALCAREOUS ARKOSE	CALCAREOUS SUBGRAYWACKE		CALCAREOUS (rock grade) CONGLOMERATE	CALCAREOUS MIXED (grade) CONGLOMERATE
IRON MINERALS Chiefly: Limonite, Siderite, Goethite, Chamosite, Hematite	HEMATITE ROCK—massive hematite LIMONITE ROCK—massive limonite BOG IRON ORE—earthy, massive, limonite IRONSTONE (Clay ironstone)—coherent mixture of iron, silica, clay, and carbonate SIDERITE (iron carbonate)—massive siderite	LIMONITIC or HEMATITIC (Ferruginous) SHALE ETC.	HEMATITE OOLITE—>50% oolitic LIMONITE OOLITE—>50% oolitic OOLITIC IRON ORE—<50% oolitic SIDERITE (iron carbonate)—chiefly siderite, crystalline	LIMONITIC or HEMATITIC (Ferruginous) LIMESTONE ETC. All varieties in the Calcite-Dolomite horizontal column are possible here	LIMONITIC or HEMATITIC (Ferruginous) QUARTZ SANDSTONE	LIMONITIC or HEMATITIC (Ferruginous) FELDSPATHIC SANDSTONE	LIMONITIC or HEMATITIC (Ferruginous) LITHIC SANDSTONE	LIMONITIC or HEMATITIC (Ferruginous) ARKOSE	LIMONITIC or HEMATITIC (Ferruginous) GRAYWACKE LIMONITIC or HEMATITIC (Ferruginous) SUBGRAYWACKE		LIMONITIC or HEMATITIC (Ferruginous) (rock grade) CONGLOMERATE	LIMONITIC or HEMATITIC (Ferruginous) MIXED (grade) CONGLOMERATE
CARBON: Humus-Yields carbonaceous derivatives; Sapropel-Yields bituminous derivatives	COAL BITUMINOUS—blocky fracture ANTHRACITE—conchoidal fracture ASPHALT—[illegible] GILSONITE—black, high luster, amorphous	CARBONACEOUS SHALE, ETC.—carbonized remains BITUMINOUS SHALE (Oil shale) ETC.—sapropelic	PEAT—dark semi-carbonized plant remains LIGNITE—brown-black, well-carbonized plant remains	CARBONACEOUS LIMESTONE BITUMINOUS LIMESTONE ETC. All varieties in the Calcite-Dolomite horizontal column are possible here	CARBONACEOUS QUARTZ SANDSTONE BITUMINOUS QUARTZ SANDSTONE	CARBONACEOUS FELDSPATHIC SANDSTONE BITUMINOUS FELDSPATHIC SANDSTONE	CARBONACEOUS LITHIC SANDSTONE BITUMINOUS LITHIC SANDSTONE	CARBONACEOUS ARKOSE BITUMINOUS ARKOSE	CARBONACEOUS GRAYWACKE ETC. CARBONACEOUS SUBGRAYWACKE ETC.		CARBONACEOUS (rock grade) CONGLOMERATE BITUMINOUS (rock grade) CONGLOMERATE	CARBONACEOUS MIXED (grade) CONGLOMERATE BITUMINOUS MIXED (grade) CONGLOMERATE
MISCELLANEOUS: Phosphate (Collophane), Evaporites: Halite and Sylvite, Anhydrite, Gypsum	PHOSPHORITE—phosphate rock ROCK SALT—massive halite or sylvite ROCK ANHYDRITE—massive anhydrite ROCK GYPSUM—massive gypsum	PHOSPHATIC SHALE, ETC.	PHOSPHATIC OOLITE—>50% oolitic ROCK SALT—crystalline ROCK ANHYDRITE—crystalline ROCK GYPSUM—crystalline GYPSUM SAND—clastic	PHOSPHATIC LIMESTONE ETC. All varieties in the Calcite-Dolomite horizontal column are possible here	PHOSPHATIC QUARTZ SANDSTONE ETC.	PHOSPHATIC FELDSPATHIC SANDSTONE ETC.	PHOSPHATIC LITHIC SANDSTONE ETC.	PHOSPHATIC ARKOSE ETC.	PHOSPHATIC SUBGRAYWACKE ETC.		PHOSPHATIC (rock grade) CONGLOMERATE	PHOSPHATIC MIXED (grade) CONGLOMERATE

The names in the above chart are root names and should be preceded by appropriate terms for any significant feature of the rock. The proper order is color, structure, grain size (sandstones only), minor constituents, cement, and root name. Structure includes, for example, "thin bedded," "massive," "cross bedded," "thinly laminated," etc. The size grade for conglomerates should immediately precede "conglomerate." Some common nonmineral minor constituent terms are "tuffaceous," "cherty," "fossiliferous," "crinoidal," "coralline," "clayey (argillaceous)," "silty," "shaly," "sandy (arenaceous)," and "conglomeratic." Minor mineralogy should follow the nonmineral composition and should be restricted to one conspicuous mineral not implied in the root name. It should be applied in adjective form as "micaceous," "chloritic," "glauconitic," and "pyritic." The most common cement terms are given in the chart with the root names. Some typical rock names are "black thin-bedded micaceous shale," "gray massive, medium-grained glauconitic [illegible] sandstone," "tan siliceous quartz pebble conglomerate," and "white vuggy foraminiferal limestone."

Graywacke currently has two meanings. To some, it denotes a feldspar quartz sandstone with more than 20 (or 15) percent pelitic matrix. To many others, it has retained its original meaning, that is a very hard, firm sandstone without porosity or chemical cement. In addition these "true" graywackes typically have extremely angular grains, a pelitic matrix, and a dark color.

FREQUENCY OF OCCURRENCE
This size type indicates COMMON ROCKS
This size type indicates UNCOMMON ROCKS
This size type indicates RARE ROCKS

Travis, R. B., 1955. Classification of Rocks,
Quarterly of the Colorado School of Mines
Vol. 50, No. 1.

APPENDIX A
(Page 2 of 3)

CLASSIFICATION OF IGNEOUS ROCKS

Russell B. Travis

ESSENTIAL MINERALS		POTASH FELDSPAR > ⅔ TOTAL FELDSPAR			POTASH FELDSPAR ⅓–⅔ TOTAL FELDSPAR			PLAGIOCLASE FELDSPAR > ⅔ TOTAL FELDSPAR					LITTLE OR NO FELDSPAR		SPECIAL TYPES
		QUARTZ >10%	QUARTZ <10% FELDSPATHOID <10%	FELDSPATHOID >10%	QUARTZ >10%	QUARTZ <10% FELDSPATHOID <10%	FELDSPATHOID >10%	POTASH FELDSPAR >10% TOTAL FELDSPAR; QUARTZ >10%	POTASH FELDSPAR <10% TOTAL FELDSPAR; SODIC PLAGIOCLASE; QUARTZ >10%	POTASH FELDSPAR <10% TOTAL FELDSPAR; SODIC PLAGIOCLASE; QUARTZ <10% FELDSPATHOID <10%	POTASH FELDSPAR <10% TOTAL FELDSPAR; CALCIC PLAGIOCLASE; QUARTZ <10% FELDSPATHOID <10%	POTASH FELDSPAR <10% TOTAL FELDSPAR; CALCIC PLAGIOCLASE; FELDSPATHOID >10% PYROXENE >10%	CHIEFLY PYROXENE AND/OR OLIVINE	CHIEFLY FERRO-MAGNESIAN MINERALS AND FELDSPATHOIDS	
CHARACTERIZING ACCESSORY MINERALS		CHIEFLY: HORNBLENDE, BIOTITE, PYROXENE, MUSCOVITE ALSO: SODIC AMPHIBOLES, AEGIRINE, CANCRINITE, SODALITE, TOURMALINE			CHIEFLY: HORNBLENDE, BIOTITE, PYROXENE ALSO: SODIC AMPHIBOLES, AEGIRINE			CHIEFLY: HORNBLENDE, BIOTITE, PYROXENE (IN ANDESITE) ALSO: PYROXENE, FELDSPATHOID, SODIC AMPHIBOLES			CHIEFLY: PYROXENE (AUGITE), OLIVINE ALSO: HORNBLENDE, BIOTITE, QUARTZ, ANALCITE, AEGIRINE, SODIC AMPHIBOLES		CHIEFLY: SERPENTINE, IRON ORE ALSO: HORNBLENDE, BIOTITE	CHIEFLY: HORNBLENDE, BIOTITE, IRON ORE	
COLOR INDEX		10	15	20	20	25	30	20	20	25	50	60	95	95	
AVERAGE CHEMICAL COMPOSITION (DALY)	SiO_2	71.5	60.4	56.0	66.E	57.0	54.1	65.3	61.6	58.2	48.6	47.4	41.1	42.0	
	Al_2O_3	14.0	17.8	19.2	15.8	17.1	21.0	16.1	16.2	17.0	16.8	15.4	4.8	17.9	
	Fe_2O_3	1.5	2.7	2.9	2.3	3.4	1.8	2.1	2.5	3.2	4.8	4.9	4.8	5.7	
	FeO	1.4	2.9	1.6	1.3	3.6	3.3	2.2	3.8	3.7	6.0	5.4	7.1	5.7	
	MgO	0.6	1.8	0.6	1.0	2.3	1.1	1.7	2.E	3.5	5.1	5.0	32.2	3.4	
	CaO	1.6	3.7	2.0	2.6	5.4	3.2	3.9	5.4	6.3	8.9	9.7	4.4	10.3	
	Na_2O	3.4	4.2	6.5	3.7	4.7	6.2	3.8	3.4	3.5	3.7	3.8	0.5	4.8	
	K_2O	4.3	5.1	5.3	4.2	3.7	5.9	2.7	2.1	2.1	1.9	3.5	1.0	2.4	
PHANERITIC	EQUIGRANULAR Batholiths, lopoliths, stocks, large laccoliths, thick dikes, and sills	GRANITE ALASKITE—few dark minerals GRAPHIC GRANITE—graphic texture ALKALI GRANITE—abundant albite and sodic amphibole or pyroxene CHARNOCKITE—with orthopyroxene LUXULLIANITE—tourmalinized	SYENITE QUARTZ SYENITE—a little quartz ALKALI SYENITE—no plagioclase except albite PULASKITE—a little nepheline NORDMARKITE—a little quartz LARVIKITE—with blue feldspar SHONKINITE—abundant FeMg minerals	NEPHELINE SYENITE LEUCITE SYENITE—analcime or zeolite instead FOYAITE—abundant feldspar MALIGNITE—abundant FeMg minerals ditroite—with nepheline and sodalite	QUARTZ MONZONITE (ADAMELLITE)	MONZONITE	NEPHELINE MONZONITE	GRANODIORITE	QUARTZ DIORITE (TONALITE)	DIORITE	GABBRO GABBRO—with clinopyroxene NORITE—with orthopyroxene OLIVINE GABBRO—with olivine TROCTOLITE—olivine and plagioclase only ANORTHOSITE—plagioclase only QUARTZ GABBRO—with quartz	DIABASE (Dolerite of British) Phaneritic diabasic texture, normally medium or fine-grained	THEOLEITE PICRITE FELSENITE—analcite only OLIVINE THEOLEITE—with olivine	PERIDOTITE PERIDOTITE—clinopyroxene and olivine HARZBURGITE—orthopyroxene and olivine PICRITE—pyroxene and olivine with some plagioclase DUNITE—olivine only PYROXENITE—pyroxene only SERPENTINE (SERPENTINITE)—chiefly serpentine	MASCOVITE—pyroxene, olivine, and phlogopite or uolite—pyroxene and olivine PERIDOTITE—pyroxene and olivine LAMPROPHYRE (MELILITE PERIDOTITE)—pyroxene and melilite	PEGMATITE—phaneromorphic-granular (or sometimes irregular mosaic) having a conspicuously coarser texture than parent. APLITE—phaneromorphic-granular rock having sugary (fine-grained allotriomorphic-granular) texture. LAMPROPHYRE—dark, dike rock with a volcanic (very phenocrysts and or no feldspar) FeMg minerals in ground mass
PORPHYRITIC	PHANERITIC GROUNDMASS Laccoliths, dikes, sills, plugs, small stocks, margins of larger masses	GRANITE PORPHYRY	SYENITE PORPHYRY	NEPHELINE SYENITE PORPHYRY	QUARTZ MONZONITE PORPHYRY	MONZONITE PORPHYRY	NEPHELINE MONZONITE PORPHYRY	GRANODIORITE PORPHYRY	QUARTZ DIORITE PORPHYRY	DIORITE PORPHYRY	GABBRO PORPHYRY	THEOLEITE PORPHYRY	PERIDOTITE PORPHYRY KIMBERLITE—peridotite porphyry or breccia		
	APHANITIC GROUNDMASS Dikes, sills, laccoliths, surface flows, margins of larger masses, welded tuffs	RHYOLITE PORPHYRY	TRACHYTE PORPHYRY	PHONOLITE PORPHYRY	QUARTZ LATITE PORPHYRY	LATITE PORPHYRY	NEPHELINE LATITE PORPHYRY	DACITE PORPHYRY		ANDESITE PORPHYRY	BASALT PORPHYRY	TEPHRITE PORPHYRY	LIMBURGITE PORPHYRY		
APHANITIC	MICROCRYSTALLINE Dikes, sills, surface flows, margins of larger masses, welded tuffs	RHYOLITE	TRACHYTE	PHONOLITE LEUCITE PHONOLITE leucite instead of nepheline TINGUAITE—abundant aegirine WYOMINGITE—leucite and phlogopite	QUARYZ LATITE (DELLENITE)	LATITE (TRACHY-ANDESITE)	NEPHELINE LATITE	DACITE		ANDESITE	BASALT OLIVINE BASALT—with olivine ANALCITE BASALT—with analcite QUARTZ BASALT—with quartz OCEANITE—with abundant olivine	TEPHRITE LEUCITE TEPHRITE—leucite only instead of nepheline BASANITE—with olivine LEUCITE BASANITE—with olivine and leucite	LIMBURGITE	NEPHELINITE—pyroxene and nepheline LEUCITITE—pyroxene and leucite MELILITITE—pyroxene and melilite OLIVINE NEPHELINITE (NEPHELINE BASALT)—pyroxene, nepheline, and olivine etc.	TRAP—dark-colored aphanitic rock. FELSITE—light-colored aphanitic rock
	GLASSY Surface flows, margins of dikes and sills, welded tuffs	OBSIDIAN—black PITCHSTONE—resinous VITROPHYRE—porphyritic PERLITE—concentric fracture PUMICE—finely cellular, light colored SCORIA—coarsely cellular, dark colored			Normally it is not possible to determine the composition of these rocks. They are customarily designated by the names at the left of this column. Basic glass is rare so rocks named, except scoria, will normally be silicic. If the approximate composition (by close association) or silica content (by refractive index or analysis), can be determined, the name may be prefixed by the name of the appropriate aphanitic rock, for example, "trachyte obsidian," or "latite vitrophyre." In general, scoria is black; basic obsidian is called "tachylite"; and sphenulitic tachylite is "variolite."			FREQUENCY OF OCCURRENCE This size type indicates COMMON ROCKS. This size type indicates UNCOMMON ROCKS. This size type indicates RARE ROCKS.				

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APPENDIX A
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CLASSIFICATION OF METAMORPHIC ROCKS

By Russell B. Travis

COLOR	CHIEF MINERALS	CHARACTERIZING ACCESSORY MINERALS	NONDIRECTIONAL STRUCTURE (Massive or Granulose) — Contact Metamorphism*		DIRECTIONAL STRUCTURE (Lineate or Foliate) — Mechanical Metamorphism	Regional Metamorphism				Plutonic Metamorphism
			Fine Grained (Aphanitic)	Medium or Coarse Grained (Phaneritic)	Cataclastic	Slaty	Phyllitic	Schistose	Gneissose	Migmatitic
LIGHT	QUARTZ FELDSPAR CALCITE DOLOMITE TALC MUSCOVITE SERICITE	Muscovite Sericite Sillimanite Kyanite Cordierite Tremolite Wollastonite Albite Andalusite Garnet Phlogopite Diopside Enstatite Staurolite Glaucophane Anthophyllite Pyrophyllite Chloritoid Actinolite Tourmaline Epidote Chiastolite Olivine Serpentine Chlorite Biotite Graphite Chondrodite Scapolite	METAQUARTZITE MARBLE BRUCITE MARBLE SOAPSTONE—chiefly talc HORNFELS—any metamorphic rock with nondirectional structure	METAQUARTZITE MARBLE BRUCITE MARBLE TREMOLITE MARBLE WOLLASTONITE MARBLE YEHMITE HORNFELS WOLLASTONITE HORNFELS CALC-SILICATE HORNFELS—chiefly calc-silicate minerals	These rocks are formed by crushing and shearing with only minor recrystallization. If there are no conspicuous fragments, the rock is called "mylonite breccia" if coarse grained, and "cataclasite" if fine grained. Most of them, however, are foliated. MYLONITE—finely ground, foliate FLASER GRANITE, FLASER DIORITE, FLASER CONGLOMERATE, ETC.—flaser structure AUGEN GNEISS—augen structure ULTRAMYLONITE—partially fused mylonite Rocks with only minor deformation may be called "schistose," for example "schistose sandstone," "schistose rhyolite," etc., but these are not properly metamorphic rocks.	Most slates are dark colored	PHYLLITE is intermediate between slate and schist. It differs from slate in that crystallization of micaceous minerals imparts a sheen to the rock; it differs from schist in that grains are too small for megoscopic identification. PHYLLONITE—a phyllite showing effects of some degree of mylonitization	QUARTZ-MICA SCHIST TALC SCHIST SILLIMANITE SCHIST ALBITE-MICA SCHIST QUARTZ-SERICITE SCHIST KYANITE SCHIST CALCITE SCHIST (schistose marble)	RHYOLITE GNEISS QUARTZ PORPHYRY GNEISS QUARTZITE GNEISS SILLIMANITE GNEISS GRANULITE—banding due to elongated quartz or feldspar grains	These rocks have a gneissose, streaked, or irregular structure produced by intimate mixing of metamorphic and magmatic materials. When they can be recognized as "mixed rock," they are called migmatite or migmatite gneiss. They may originate by injection (injection migmatite, injection gneiss, or lit-par-lit gneiss), or by differential fusion. Many so-called migmatites probably originate by partial granitization or by metamorphic differentiation. But at great depth these processes apparently do not differ substantially from the igneous processes forming migmatite, so the products are usually indistinguishable. Migmatites are named by prefixing the rock name of the granitic material to the appropriate root as "granite migmatite," "monzonite injection migmatite," etc.
INTERMEDIATE (Includes Red or Brown)	ABOUT EQUAL PROPORTIONS OF LIGHT-COLORED AND DARK-COLORED MINERALS		METAQUARTZITE MARBLE SKARN—pyroxene-garnet-carbonate hornfels SOAPSTONE—chiefly talc HORNFELS—any metamorphic rock with nondirectional structure SERPENTINE*	METAQUARTZITE MARBLE DIOPSIDE MARBLE CHONDRODITE MARBLE ANDALUSITE HORNFELS SKARN—pyroxene-garnet-carbonate hornfels GARNET HORNFELS KYANITE HORNFELS ANTHOPHYLLITE HORNFELS CALC-SILICATE HORNFELS SERPENTINE* CORDIERITE-ANTHOPHYLLITE HORNFELS				MICA SCHIST CHIASTOLITE SCHIST ANDALUSITE SCHIST STAUROLITE SCHIST KYANITE SCHIST STAUROLITE-KYANITE SCHIST GARNET-MICA SCHIST SERPENTINE* TOURMALINE-MICA SCHIST ANTHOPHYLLITE SCHIST STAUROLITE-KYANITE SCHIST SILLIMANITE-GARNET SCHIST GRAPHITE SCHIST CALCITE SCHIST (schistose marble) SCHISTOSE QUARTZITE	GRANITE GNEISS SYENITE GNEISS MONZONITE GNEISS GRANODIORITE GNEISS ANORTHOSITE GNEISS TRACHYTE GNEISS CONGLOMERATE GNEISS ARKOSE GNEISS SANDSTONE GNEISS AUGEN GNEISS—augen structure BIOTITE GNEISS STAUROLITE GNEISS PLAGIOCLASE GNEISS GARNET GNEISS MUSCOVITE-BIOTITE-QUARTZ GNEISS KYANITE GNEISS GRANULITE—banding due to elongated quartz or feldspar grains	
DARK (Includes Green)	QUARTZ CALCITE DOLOMITE FELDSPAR CHLORITE HORNBLENDE SERPENTINE BIOTITE PYROXENE ACTINOLITE EPIDOTE OLIVINE MAGNETITE		METAQUARTZITE MARBLE SKARN—pyroxene-garnet-carbonate hornfels GRAPHITE MARBLE CHLORITE MARBLE SERPENTINE MARBLE (Oph-calcite) HORNFELS—any metamorphic rock with nondirectional structure SERPENTINE*	METAQUARTZITE MARBLE GRAPHITE MARBLE CHLORITE MARBLE OLIVINE MARBLE SKARN—pyroxene-garnet-carbonate hornfels ACTINOLITE MARBLE ACTINOLITE-EPIDOTE HORNFELS ACTINOLITE HORNFELS PYROXENE HORNFELS EPIDOTE HORNFELS TOURMALINE HORNFELS ANDALUSITE BIOTITE HORNFELS SERPENTINE* ECLOGITE—garnet-amphibole hornfels MAGNETITE ROCK CORDIERITE HORNFELS AMPHIBOLITE—chiefly hornblende and or plagioclase	SILTY SLATE CARBON SLATE BLACK SLATE SPOTTED SLATE ANDALUSITE SPOTTED SLATE CHIASTOLITE SPOTTED SLATE BIOTITE SPOTTED SLATE CARBONACEOUS SLATE CALCAREOUS SLATE		GREENSCHIST CHLORITE SCHIST CHLORITOID SCHIST GLAUCOPHANE SCHIST AMPHIBOLITE (HORNBLENDE SCHIST) ACTINOLITE SCHIST GRAPHITE SCHIST PYROXENE SCHIST EPIDOTE-CHLORITE SCHIST HORNBLENDE-BIOTITE SCHIST BIOTITE-CHLORITE SCHIST SERPENTINE* TOURMALINE SCHIST EPIDOTE AMPHIBOLITE GARNET-PYROXENE AMPHIBOLITE GARNET-CHLORITE SCHIST	QUARTZ DIORITE GNEISS DIORITE GNEISS GABBRO GNEISS PERIDOTITE GNEISS DIABASE GNEISS PYROXENE GNEISS GRAYWACKE GNEISS EPIDOTE GNEISS GARNET-BIOTITE GNEISS SKARN GNEISS AMPHIBOLITE GNEISS	

As can be noted from the chart, naming a metamorphic rock consists chiefly of prefixing the structural term with mineral names or an appropriate rock name. The rock name indicates either the original rock, if recognizable, or the new mineral composition. The prefix "meta," as "metagabbro," "metasandstone," "metatuff," etc., is applied to rocks that have undergone considerable recrystallization but have largely retained their original fabric. Most of the minerals listed as accessories are generically important and if present should be included in the rock name regardless of their quantity.

*SERPENTINE is a product of hydrothermal alteration which some authorities consider to be an igneous process and others a metamorphic process. For this reason serpentine appears both on this chart and on the igneous rock chart.

FREQUENCY OF OCCURRENCE
This type indicates COMMON ROCKS.
This type indicates UNCOMMON ROCKS.
This type indicates RARE ROCKS.

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APPENDIX B

SSC PROJECT-SPECIFIC ADDITIONAL CORING PROCEDURES

APPENDIX B

The Earth Technology coring procedure (F-3-1) was developed as a general guideline for coring operations and core logging. In the case of the SSC project, additional procedures were used during field operations to better describe the geology encountered at the site. The procedures and their correspondence with the F-3-1 procedure are included in this appendix.

Forthcoming (Final)