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MASTER

QUANTITATIVE PETROSTRUCTURE ANALYSIS

Technical Summary Report

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This report summarizes the key features of the Petrostructure Analysis program being developed at UCLA under DOE support (DE-AS03 - 76SF 00034, PA# DE - AT03 - 76ER70224) in conjunction with G-5 and G-4 at Los Alamos Scientific Laboratory. The period covered is January 1980 - August 1980.

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INTRODUCTION

It has long been recognized that correlations exist between observable crack patterns, mineral grain texture (or rock fabric) and bulk mechanical properties. Among others, Brace (1965) and Friedman and Bur (1974) have demonstrated such relationships. However, such work has not been done in a way so as to generate mathematical tools which allow prediction of the behavior of pressure-dependent mechanical properties over a large range of rock types.

In a study which addressed this problem, Warren and Trice (1975 & 1977) showed that over a large spectrum of rock types, from competent granites to porous sandstones and breccias, the functional forms of velocity-pressure data exhibit predictable behavioral regularities (i.e., systematics) which are characteristic of the texture and fabric of that specific rock type. Continuing this work in a more quantitative vein, Warren (1977) further showed that such regularities can be represented in terms of a fairly general theoretical model of crack and pore behavior. Warren and Tiernan (1980) extended the concept of the preceding work to rocks within one class of similar fabric and texture. The study demonstrated that the much smaller texture and fabric differences between rocks with essentially the same mineralogy and geologic history are reflected in systematic pressure-dependent mechanical property differences.

All of these studies have highlighted the need to be able to quantify descriptions of rock mineralogical, textural, and crack and pore variables.

Quantitative studies of rock texture and microstructure can be done on local scales, but larger or "global average" petrographic descriptions are

qualitative. On the other hand, physical and mechanical properties are measures of global and volume averaged rock mineralogical and textural variables. Therefore, more generalized and moderately economical techniques to quantitatively parameterize rock structures from direct observation are needed.

The establishment of such quantitative techniques would lead to the development of predictive tools which would be of obvious importance in applied geophysics and engineering. In rock physics, it would help establish laws for averaging the effects of finite densities of real cracks and pores. It would also help in elucidating the relation between observed complex crack structures and various models for the mechanical properties of single cracks. The petrostructure study is addressed to this problem. The purpose of the effort is to quantitatively characterize the mineral and crack texture of granitic rock samples pertinent to HDR. The rock structures are to be characterized in such a way that the results can be used (1) to constrain the modelling of the effect of cracks on the physical properties of rocks, and (2) to test the possibility of establishing quantitative and predictive relations between petrographic observables and whole rock properties.

Statistical techniques are being developed and being applied to the problem of parameterizing complex texture and crack patterns of rock, and of measuring correlation of these parameters to other measurable variables (such as velocity data). The study is an application in Factor Analysis. (Joreskog, et al., (1976); Davis, (1973); Kowalski, (1977).

The remainder of this report briefly outlines the logic of the technique,

and summarizes the status to date. Applications to a study of the grain texture of Berkeley Blue Granite is expected to be made this Fall.

NOTION OF PETROSTRUCTURE

The petrostructure can be defined as the architecture of a rock. It includes the building material (mineral modes), the solid state construction (the 3-dimensional spacial relations between all the building components, such as crystals and glass, etc.) and the flaw and void structure (e.g., dislocations, vugs, cracks, etc.) of the rock.

It may therefore be thought of as a name for the space spanned by three axes: the mineralogical variables, the petrographic variables, and the microstructure (microcrack) variables.

PETROSTRUCTURE MODEL SPACE

Any particular rock has its own petrostructure. It also has unique physical bulk properties (e.g., stress-strain coefficients, electrical and fluid transport properties). Therefore, the Petrostructure Space is the modelling space for bulk physical and mechanical properties, that is, classes of such properties can be mapped into classes of allowable petrostructure.

PETROSTRUCTURE STATISTICAL SPACE

The petrostructure description of a rock is a statistical description. Within any one rock, the values of the petrostructural variables form distributions. Therefore, the description region for a rock is canonical in these variables. Consequences that follow from this:

- The measure of the similarity of two different rocks

is a statistical measure.

- Similarity classes of groups of rocks can be defined.
- The relation between physical and mechanical properties and petrostructure is in the form of statistical correlation.

PETROSTRUCTURE VARIABLES

The variables fall broadly into two classes of forms:

- (1) Topographic
- (2) Compositional

The compositional variables (e.g., chemistry and mineralogy) are fairly directly quantifiable. Topographic variables are patterning variables which must be quantified through mapping. They include grain orientation, mineral nearest-neighbor distances, crack patterns and crack hierarchies. These topographic variables can be evaluated by inventing a mapping technique which preserves the statistics of the relations which can then be directly evaluated in terms of a small fixed set of map parameters. Three sets of map parameters have been chosen:

- (1) sets of coordinate points (x, y)
- (2) listings of connected points $(n_1, n_2, \dots, n_j)$
- (3) flag values (F_j) which specify the nature of connectivity.

NOTION OF A PETROSTRUCTURE ANALYSIS

The petrostructure analysis itself then is composed of four logic blocks:

- (1) The quantitative parameterization of topographic variables (program: DIGITIZATION)
- (2) The analysis of the mapped patterns into new distributions of statistical variables (program: SOCIOLOGY) which are in the same numerical form as compositional variables. This part of the analysis is basically pattern parameterization.
- (3) The forming of an evaluated matrix over all variables of interest. This is basically the filling of the region occupied by a rock in Petrostructural space (program: NAME).
- (4) Statistical analysis for correlations and cross-correlations between variables, and groups of data from suites of rocks, etc. (programs: various available problems, e.g., BIO-MED PROGRAM, UCLA).

PROGRAM LOGIC

Digitization

DIGITIZATION is actually a block of several sub-programs and subroutines which generate input for the statistical crack-pattern analysis program being developed at UCLA.

Input consists of map descriptions of microstructure and rock texture observed in rock thin sections.

The basic map information consists of coordinates of nodes and/or junctions and the ordered connectiveness of these nodes.

At UCLA, the program for ordering this digitized data has been written. Computer plots of the initial data can be generated, effectively producing computer maps of a rock section, to whatever degree of resolutions we initially chose for analysis. The process follows:

- Microphotographs of thin sections showing the salient features are enlarged for digitization.
- Digitization at UCLA is done on a SAC graf/pen digitizer tied to a 1000 Hewlett-Packard Minicomputer. The program for digitizing is called MAPS. The output is a file called INAME which contains coordinate connectivity and flag information.
- Flag information describes the intrarelationship of any particular sequence of connected coordinates. For example, a flag value=1 may be chosen to specify that the digitized points represent a connected open crack, or a grain boundary, etc.
- The digitized data can, at this level, be plotted as a map (subroutine PLOT) for comparison to the original microphotograph.

Figures 1 and 2 show a negative of a microphotograph for Conway Granite Sample 704.4, and the PLOT created mapped portion of the negative. Digitization at LASL is being developed through Andrea Eddy, Group G-4, LASL. Two techniques for digitization are being explored. The most powerful technique involves using a microdensitometer to scan microphotographs, and then digitizing the microdensitometer data using image enhancement techniques (DIADS, by J. Breedlove, M-5). The second method is to digitize the microphotographs directly using a Hewlett Packard digitizing tablet (model 9874A, located with Group G-7 at LASL).

The second and third major sub-programs in this section consist of a program for transferring map data to the main UCLA 3033 computer, reading in additional header information, performing a data clean up (CLEAN UP), and organizing the data for direct access by SOCIOLOGY.

A main function of CLEAN UP is to test for single points which have been digitized more than once (e.g., at a crack fork), and which therefore need to be prescribed by a single coordinate value.

The flow chart for MAPS is given on page 17. Flow charts for the second portion of the program are given on pages 18 through 26.

Figures 3 and 4 show the original microphotographed and a CLEANED UP map section for Conway Granite sample 704.4.

Sociology

SOCIOLOGY is a pattern parameterization program. It consists of three main subroutines which we are presently interconnecting by choice in a large DO LOOP.

Input to SOCIOLOGY consists of point coordinates of nodes and point-connections. This primary data is arranged into a table of points, and distances and angles to its (up to 6 other) nearest connected neighbors. For example, a point at the end of a line (or crack) has one neighbor ($J=1$). A kink point in a crack has 2 neighbors ($J=2$), a branch point in a crack has 3 neighbors ($J=3$), etc. Tables can be generated for any suite of data keyed by chosen flag values. An example of input and its generated table is given on pages 28, 29, and 30.

The table is then the basic matrix operated on by the three main subroutines: PRUNE, BORDER, PSEUDO CLOSURE. Flowcharts for PRUNE and BORDER are given on pages 31 and 32.

PRUNE decomposes any open line network in a step-wise process. For example, subparallel cleavage cracks or a dendritic crack pattern would be "erased" in PRUNE, and decomposed into distributions such as line lengths, angles, tortuosity (kink-lengths) and connectiveness (crack fork and intersection densities).

BORDER decomposes any remaining map network of closed paths, for example, crack grains or mineral grains. Output consists of such specifiable quantities as grain areas, edge lengths, and measures of grain size, shape orientation, and grain-grain neighbor distances.

PSEUDO CLOSURE generates a measure of crack pattern closure. New virtual or pseudo-cracks are extended from the free ends of existing cracks to test the probability of two cracks connecting. The subroutine generates a distribution of new virtual cracks. These cracks can be used to augment the initial table for PRUNE and BORDER, to give, for example, a measure of crack populations

needed to fail a material.

During Fall, 1980, SOCIOLOGY will be modified to increase its interactive flexibility.

A partial sociological characterization of a crack pattern is given in Figure 5.

Name

NAME, for a rock, is a large normalized table of about 100 variable values, generated by and also augmented to the output from SOCIOLOGY. NAME is, in brief, the factor space for factor analysis of rock petrostructure and physical properties. For example, comparison of two different rock samples (I and J) is measured by correlation of NAME(I) and NAME(J), and/or their subnames.

The schematic form of NAME is shown below.

This program will therefore be the main storage matrix of data which interfaces SOCIOLOGY, and augmented data such as mineralogy, composition, and physical variables such as velocity in a single format for statistical study. NAME will be fully accessed, allowing screen and hard copy displays of chosen subname data, and will be integrated with the statistical analysis package which we plan to use.

We do not expect to complete NAME this grant period. At present, the output from SOCIOLOGY and any other set of data to which we wish to form correlations must be simply compiled and organized by hand. A schematic of the variable storage for NAME is given on pages 35 and 36.

Statistical Analysis

Output from SOCIOLOGY or from NAME is applicable to various levels of statistical analysis. On the first level, the output is an analysis itself in terms of mean values, first variations, and distributions or histograms. On the next level, we have available a program for binning histograms of classes. The program allows pairwise correlations of three "independent" evaluated variables against all the other "dependent" variables grouped by subclasses or subnames.

We are currently developing our program to interface with the UCLA Bio Medical Program, which allows a number of high-order correlation measures to be made on up to 999 variables.

Finally, the data is applicable to Abstract Factor Analysis programs, such as through BMD, or to programs which can be developed along the lines of Matinowski (1977).

Conway granite

Sample 704.4g

photo #7

mag = x400

date = 7/28/77

Figure 1

computer map
initial digitization
704.4 photo #7
mag = x400
reflection photograph
7/26/77

LALS : STOP ^200
: 2 july 1980

Figure 2

Conway granite

Sample 704.4g

photo #6

mag = X63

date = 7/16/78

Figure 3

Figure 4

Conway Granite Sample #704.4 g
Photo #6
Mag = X63
Date = 7/16/78
CLEANED UP MAP

read data, flag, count the number of points in each set, count the number of sets, count the total number of points.

test for points which lie within 0.025 in. of each other; when two such points are found, change the coordinate of the second point (a "redundant point") to those of the first (a "primary" point) and keep a record of such change

output parameter for the plot route,
specifying data number, symbol, etc.

output for connection of points

Format now can be read directly by
SOCIOLOGY

ROCK I.D.NU . 381.9

GRID SPACING: 0.0025

GRID COUNT IS: 50

MAGNIFICATION, DIAMETERS : 63

UNIT LENGTH IS HERE: 0.00099

GRID AREA IS: 0.00246

Node #	Row	Column
1	91.000	7.000
2	94.000	23.000
3	96.000	38.000
4	96.000	51.000
5	88.000	60.000
6	80.000	67.000
7	85.000	71.000
8	98.000	69.000
9	104.000	50.000
10	105.000	75.000
11	101.000	82.000
12	90.000	79.000
13	85.000	87.000
14	85.000	99.000
15	82.000	111.000
16	70.000	126.000
17	53.000	145.000
18	37.000	153.000
19	32.000	175.000
20	25.000	163.000
21	29.000	156.000
22	19.000	150.000
23	7.000	132.000
24	0.0	124.000
25	0.0	90.000
26	7.000	90.000
27	16.000	91.000
28	25.000	78.000
29	39.000	73.000
30	47.000	73.000
31	62.000	83.000
32	71.000	88.000
33	77.000	117.000
34	104.000	85.000
35	110.000	80.000
36	119.000	80.000
37	138.000	66.000
38	148.000	9.000
39	161.000	33.000
40	159.000	41.000
41	148.000	45.000
42	155.000	47.000
43	162.000	49.000
44	167.000	59.000
45	165.000	72.000
46	153.000	80.000
47	161.000	76.000

Node #	Row	Column
48	292.000	129.000
49	130.000	92.000
50	132.000	100.000
51	139.000	107.000
52	146.000	111.000
53	158.000	129.000
54	162.000	143.000
55	162.000	150.000
56	162.000	166.000
57	160.000	186.000
58	163.000	197.000
59	154.000	199.000
60	159.000	200.000
61	183.000	218.000
62	114.000	147.000
63	156.000	148.000
64	171.000	154.000
65	175.000	155.000
66	282.000	145.000
67	300.000	148.000
68	306.000	162.000
69	304.000	174.000
70	174.000	1.000
71	187.000	6.000
72	194.000	3.000
73	233.000	20.000
74	242.000	26.000
75	285.000	49.000
76	302.000	60.000
77	331.000	79.000
78	341.000	81.000
79	359.000	102.000
80	368.000	117.000
81	333.000	92.000
82	306.000	114.000
83	320.000	116.000
84	342.000	104.000
85	352.000	105.000
86	302.000	116.000
87	309.000	124.000
88	303.000	130.000
89	307.000	141.000
90	184.000	129.000
91	165.000	69.000
92	183.000	75.000
93	340.000	1.000
94	339.000	26.000
95	378.000	27.000

Node #	Row	Column
96	402.000	30.000
97	429.000	29.000
98	426.000	24.000
99	461.000	29.000
100	465.000	28.000
101	414.000	17.000
102	380.000	2.000
103	510.000	72.000
104	486.000	81.000
105	465.000	70.000
106	440.000	67.000
107	428.000	65.000
108	414.000	66.000
109	398.000	60.000
110	387.000	60.000
111	375.000	55.000
112	367.000	56.000
113	357.000	56.000
114	352.000	54.000
115	335.000	73.000
116	373.000	123.000
117	282.000	170.000
118	250.000	160.000
119	237.000	164.000
120	212.000	167.000
121	197.000	177.000
122	188.000	174.000
123	171.000	192.000
124	45.000	190.000
125	39.000	200.000
126	26.000	201.000
127	28.000	192.000
128	24.000	182.000
129	15.000	181.000
130	4.000	197.000
131	0.0	200.000
132	14.000	172.000
133	1.000	145.000
134	8.000	163.000
135	0.0	160.000
136	13.000	209.000
137	8.000	230.000
138	25.000	267.000
139	0.0	249.000
140	34.000	304.000
141	48.000	311.000
142	54.000	317.000
143	68.000	332.000

CONNECTIVITY	ADJACENCY	DATA
1	1	2
2	2	3
3	3	4
4	4	5
5	5	6
6	7	8
7	8	9
8	9	10
9	10	11
10	11	12
11	12	13
12	13	14
13	14	15
14	15	16
15	16	17
16	17	18
17	18	19
18	19	20
19	20	21
20	21	22
21	22	23
22	23	24
23	25	26
24	26	27
25	27	28
26	28	29
27	29	30
28	30	31
29	31	32
30	32	33
31	33	34
32	34	35
33	35	36
34	36	37
35	38	39
36	39	40
37	40	41
38	42	43
39	43	44
40	44	45
41	45	46
42	47	48
43	36	49
44	49	50
45	50	51
46	51	52
47	52	53
48	53	54
49	54	55
50	55	56
51	56	57
52	57	58
53	59	60
54	60	61
55	62	63
56	63	65
57	65	64

CONNECTIVITY	ADJACENCY	DATA
64	72	73
65	73	74
66	74	75
67	75	76
68	76	77
69	77	78
70	78	79
71	79	80
72	81	82
73	82	83
74	83	84
75	84	85
76	86	87
77	87	88
78	88	89
79	54	90
80	91	92
81	93	94
82	94	95
83	95	96
84	96	97
85	97	98
86	98	99
87	99	100
88	101	102
89	103	104
90	104	105
91	105	106
92	107	108
93	108	109
94	109	110
95	110	111
96	111	112
97	112	113
98	113	114
99	114	115
100	115	77
101	77	80
102	80	116
103	117	118
104	118	119
105	119	120
106	120	121
107	122	123
108	123	58
109	19	124
110	124	125
111	125	126
112	126	127
113	127	128
114	128	129
115	129	130
116	130	131
117	130	132
118	132	133
119	134	135
120	130	136
121	134	137

CONNECTIVITY	ADJACENCY	DATA
128	145	146
129	146	147
130	147	148
131	149	150
132	151	152
133	152	153
134	153	154
135	154	155
136	155	156
137	156	157
138	157	158
139	158	159
140	159	160
141	160	161
142	162	159
143	159	163
144	163	164
145	165	166
146	165	167
147	168	169
148	169	177
149	156	170
150	170	171
151	171	172
152	172	173
153	173	174
154	174	175
155	175	176
156	176	177
157	177	178
158	178	179
159	179	180
160	180	181
161	181	182
162	182	183
163	183	184
164	184	185
165	185	143
166	186	187
167	187	188
168	188	189
169	189	190
170	190	191
171	191	192
172	192	193
173	193	194
174	195	196
175	196	197
176	198	199
177	199	200
178	200	201
179	201	202
180	202	203
181	203	204
182	204	205
183	205	206
184	206	207
185	207	208

NODE	X	Y	DEG	1N	DIST	ANGLE	2N	DIST	ANGLE	3N	DIST	ANGLE	4N	DIST	ANGLE
1	7.	91.	1	2	16.28	79.38		0.0	0.0	0	0.0	0.0	0	0.0	0.0
2	23.	94.	2	1	16.28	259.38	3	15.13	82.41	0	0.0	0.0	0	0.0	0.0
3	38.	96.	2	2	15.13	262.40	4	13.00	90.00	0	0.0	0.0	0	0.0	0.0
4	51.	96.	2	3	13.00	270.00	5	12.04	131.63	0	0.0	0.0	0	0.0	0.0
5	60.	88.	2	4	12.04	311.63	6	10.63	138.81	0	0.0	0.0	0	0.0	0.0
6	67.	80.	1	5	10.63	318.81	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
7	71.	85.	1	8	13.34	347.01	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
8	68.	98.	3	7	13.34	167.01	9	18.97	288.44	10	9.90	45.00	0	0.0	0.0
9	50.	104.	1	8	18.97	108.43	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
10	75.	105.	2	8	9.90	225.00	11	8.06	119.74	0	0.0	0.0	0	0.0	0.0
11	82.	101.	2	10	8.06	299.75	12	11.40	195.25	0	0.0	0.0	0	0.0	0.0
12	79.	90.	2	11	11.40	15.26	13	9.43	122.01	0	0.0	0.0	0	0.0	0.0
13	87.	85.	2	12	9.43	302.01	14	12.00	90.00	0	0.0	0.0	0	0.0	0.0
14	99.	85.	2	13	12.00	270.00	15	12.37	104.04	0	0.0	0.0	0	0.0	0.0
15	111.	82.	2	14	12.37	284.04	16	19.21	128.66	0	0.0	0.0	0	0.0	0.0
16	126.	70.	3	15	19.21	308.66	17	25.50	131.82	33	11.40	307.88	0	0.0	0.0
17	145.	53.	2	16	25.50	311.82	18	17.89	153.43	0	0.0	0.0	0	0.0	0.0
18	153.	37.	2	17	17.89	333.44	19	22.56	102.80	0	0.0	0.0	0	0.0	0.0
19	175.	32.	3	18	22.56	282.80	20	9.90	225.00	124	19.85	49.09	0	0.0	0.0
20	168.	25.	2	19	9.90	45.00	21	12.65	288.44	0	0.0	0.0	0	0.0	0.0
21	156.	29.	2	20	12.65	108.43	22	12.53	208.61	0	0.0	0.0	0	0.0	0.0
22	150.	18.	2	21	12.53	28.61	23	21.10	238.57	0	0.0	0.0	0	0.0	0.0
23	132.	7.	2	22	21.10	58.57	24	10.63	228.81	0	0.0	0.0	0	0.0	0.0
24	124.	0.	1	23	10.63	48.81	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
25	90.	0.	1	26	7.00	0.00	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
26	90.	7.	2	25	7.00	180.00	27	12.73	315.00	0	0.0	0.0	0	0.0	0.0

Caption to Figure 5

The figure shows a partial SOCIOLOGICAL analysis of a crack pattern for an X63 magnification photograph of Conway granite sample 381.9.

a: Distribution of node neighbors. The initial distribution consisted of 4 free points ($J = 0$), 36 free ends ($J = 1$), 20 kinks ($J = 2$), 13 forks ($J = 3$), and no intersections ($J = 4$). During the reiterative PRUNE cycle, populations of line segments were erased until there were no free ends ($J = 1$). This took 5 cycles (not all indicated).

b: Cumulative crack length as function of PRUNE cycle. During the 5 PRUNE cycles, approximately one-half of the total crack length was erased. That is, this is one-half of the total crack length connected in a branching, open dendretic network.

c: Length distribution of crack segment during PRUNE. The form of the length distribution stays essentially constant after the first cycle which removed proportionately more short than long segments.

d: Distribution of grain size to grain shape. The suggestion (for a larger sampling) is that grains are approximately equidimensional. Small grains draw a distribution of flatnesses.

e: Distribution of line segment lengths added under pseudoclosure. This is a measure of the granularity of the crack network. The crack network is closed by the addition of many short crack segments.

Examples of NAME characterization

Subname: MINERAL

R	M ₁	M ₂	M ₃	M ₄					
FLAG	G	σ_G	F	σ_F	S _{ij}	σ_{ij}	UNIF	NBRI	
FLAG									

1. R = key number for rock
2. M₁, M₂, M₃, M₄ = major mineral modes
3. FLAG = numeric; mineral type, M₁,.....M₄
4. G, σ_G = mean grain size and standard deviation.
5. F, σ_F = mean grain flatness and standard deviation.
6. S_{ij}, σ_{ij} = nearest neighbor distance, mineral type pair-wise (i,j) and standard deviation.
7. UNIF = measure of grain size to nearest neighbor distance for each type of grain
8. NBRI = key name of nearest neighbor mineral type

Items 4 - 8 are directly obtainable as output from SOCIOLOGY given input maps of rock texture keyed by mineral.

Subname: CRACKS

R										
FLAG	L _T	l_{11}	σ_{11}	l_{13}	σ_{13}	NJ ₃	NJ ₁	σ_{11}	σ_o	τ
										

1. R = key number for rock
2. FLAG = crack population type
3. L_T = cumulative crack length/unit area
4. l_{11} , σ_{11} = mean length of straight cracks and standard deviations
5. l_{13} , σ_{13} = mean length of crack segments from free end to branch point, and standard deviation
6. NJ₃ = number density of branch points/unit area

7. NJ_1 = number density of cracks ends/unit area
8. θ, σ_θ = mean preferred orientation and standard deviation
9. τ = crack segment length to branch point spacing

Items 2 - 9 are directly obtainable from PRUNE cycling.

L_p	G	σ_G	F	σ_F	S	σ_S
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10. L_p = closed crack length/unit area
11. G, σ_a = crack-grain mean size and standard deviation
12. F, σ_F = mean grain flatness and standard deviation
13. S, σ_S = mean separation between crack-grains and standard deviations

Items 10 - 13 are output from BORDER

Subname: CRACK SPECTRA

CRACK SPECTRA (or other single-valued functions of a free variable such as pressure) may be represented by a) characteristic pressures (peaks or troughs in function) and b) peak heights. The particular choices depends on the problem at hand, and need to be normalized for NAME and factor analysis.

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