Geological Circular 74-3

A NUMERIC CODE FOR DESCRIBING ROCKS IN SEDIMENTARY BASINS

BY
E.G. WERMUND AND CHARLES A. CAUGHEY

BUREAU OF ECONOMIC GEOLOGY
THE UNIVERSITY OF TEXAS AT AUSTIN
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A NUMERIC CODE FOR DESCRIBING ROCKS IN SEDIMENTARY BASINS

E. G. Wermund and Charles A. Caughey

INTRODUCTION

The purpose of this paper is to present a system of encoding rock data for multiple uses that include (1) mapping subsurface stratigraphy for economic exploration, (2) cataloging borings used in subsurface waste disposal, and (3) building a library of natural resource information.

Regional surface and subsurface stratigraphic studies for exploration in sedimentary basins commonly require the handling of numerous columnar sections that display rock descriptions collected from both outcrop and borings. Data of the borings are core descriptions, logs of cuttings or ditch samples, and mechanical logs of physical properties such as self potential, resistivity, gamma, gamma-neutron, and others. It is not unusual in a regional problem for a geologist to use columnar data from 2,500 or more localities (Wermund and Jenkins, 1970; Galloway and Brown, 1972). One way of handling large stratigraphic data files is to describe the rocks in a computer-compatible format. Whenever lithofacies mapping or statistical analyses become a required means toward solving regional stratigraphic problems, a numerical encoding system to describe the rocks becomes valuable. Although there is a large literature on solving regional problems including various numerical (or lithofacies) mapping techniques, little has been written about methods for encoding rock data. At least, the writers are unaware of many published systems for encoding lithologic descriptions.

There is considerable evidence (Galley, 1968) that the problem of disposing of man's wastes will increase in size and complexity and that waste disposal into deep wells will become more common than now. This will be especially true regarding disposal of radioactive wastes (Kubo and Rose, 1973). A catalog of possible deep disposal sites for which the lithologic sequence is encoded will be a valuable adjunct to decision making. Even for shallow pits at the surface which are more in demand the encoding of lithology will be useful.

Related to the above needs, increased interest in the construction of environmental and natural resource inventories gives further impetus toward encoding rocks. This interest concerns ongoing active legislation to formulate land use policy and law. Government agencies at all levels, foreseeing their responsibilities in land management, actively discuss many kinds of classification and information systems, one of which is always a natural resources information system. Examples are land use classification (Anderson, Hardy, and Roach, 1972), the proposed nationwide RALI information system formulated by the U. S. Geological Survey (Clarke, 1973), and a Texas natural resources information system (Interagency Council on Natural Resources and Environment, 1973). Part of any natural resources information system requires the description of typical sections of rock in representative or critical geographic regions. If these natural resources systems are to be computer-compatible, then a lithologic encoding system will be an essential element.

The scope of this paper is to present a numerical encoding system (table 1) to describe rocks.

SELECTION OF DESCRIPTORS

PREMISES

In formulating the numerical encoding of lithology (table 1), some premises are arbitrarily imposed which restrict the final choice of rock descriptors. These premises or rationales are:

1. The lithologic encoding system is part of a larger system, e.g., basin analysis, catalog of waste disposal sites, or inventory of natural resources.

2. Each rock or lithologic change is described on one punched card of 80 columns and 10 rows.

3. Rocks of sedimentary basins are described; detailed studies of igneous and/or metamorphic terranes or basements may require additional categories or more probably a new encoding system.

4. The rock is described in only essential component parts, excluding pore fluids (excepting shows of hydrocarbons) and interpreted data of environment of deposition, economic potential, etc.

5. The data source can be the rocks themselves or lithologic interpretation of mechanical logs or geophysical measurements from outcrop or subcrop.

6. The encoding system has utility for basin analysis independent of stratigraphic nomenclature and terminology; i.e., one may employ the code within classical stratigraphy (Forgotson and Iglehart, 1967), depositional systems (Fisher and McGowen, 1967), or geometric slices.

7. Stratigraphic tops or boundaries are interpretations and belong in a separate card class not encoded with lithology.

LOCATING LITHOLOGIC INTERVALS

As the numeric code is designed to be a subsystem, one space [column 1] is reserved to identify the lithologic code for sedimentary basins. Although fewer than 10 geologic card types are listed (table 1), it is visualized that the 11 and 12 punch rows could be used, accommodating up to 30 geologic card types. Examples of other card types that could be included for general use are stratigraphic tops, fluids, production in history, and economic deposits; card types having only specialized use might be created out of paleontological, sedimentological, or structural studies.

The commonality which interrelates all the information of each subsystem (card type) consists of accurately located geographic coordinates [columns 68-80] and elevation [columns 3-23]. Therefore, it seems appropriate to create an essential reference subsystem—a Location Card—that has both location and a list of all kinds of data available at each locality. That subsystem is not presented here. After some consideration it was determined that location and elevation data should also be included in the lithologic code for sedimentary basins making the subsystem independent for subsurface mapping.

The choice of a location system is important. Previous workers studying numerous outcrops and borings have employed a location code of a county number [columns 3-5] and a location number [columns 6-9] for field book locations or files of borings in the form of mechanical logs, sample logs, and core descriptions. This older system, resurrected here, requires seven spaces permitting as many as 9999 locations in 999 counties (or other subdivisions). In addition, location can be stated to the nearest 10 meters using the Universal Transverse Mercator Coordinates which require 13 spaces [columns 68-80]. The problem of mapping in adjacent UTM zones may be solved by using the 11 and 12 punch rows available in the designated columns or referring to a Location Card. If preferred, the same 13 columns

can be used for latitude and longitude to the nearest second. For use worldwide, the 11 and 12 punch fields must be used to identify N-S latitude and E-W longitude.

As this code will be used for mapping surface and subsurface data of sedimentary basins, elevation and thickness of sedimentary units are interdependent. Fourteen columns [columns 10-23] are assigned to elevation and interval thickness. Four columns are used to locate a base elevation of less than 10,000 feet, the base elevation of a measured section of an outcrop or surface elevation of a boring. Texas has a maximum elevation of 8751, but where 10 and 20 thousand feet elevations are needed, 11 and 12 punched rows may be used. Reference must be made to the data source [column 2] to know if the elevation refers to outcrop or boring. Five columns each are designated for either the height above the base of a measured outcrop section or the drilling depth to the top and bottom of lithologic intervals. It is thus possible to identify lithologic intervals of the deepest known exploration borings. Also, the combination of surface elevation and depth of intervals are readily computed to mean sea level.

Because the code is designed for describing rotary drill cuttings or ditch samples as well as whole rocks, some additional columns are needed. The cuttings from any one sample interval commonly contain more than one rock type, because nearby lithologic intervals mix together during the lag time while cuttings are circulated out of the borings. Each lithology requires a description and 2 columns [columns 24-25] to identify a card number of several cards—usually two or three rock types. In addition, the percentage of each rock type [columns 66-67] is encoded. Finally, the data source must be punched as row 3 in column 2.

ROCK DESCRIPTION

Columns 26-65.—To identify and locate the lithologic interval requires 38 columns; the remaining 40 columns [columns 26-65] describe the rock. The major descriptive elements include rock name, color, texture, structure, minerals, fossils, and pore space.

Columns 33-34.—The list of rock types allows the possibility of describing either a single rock type or commonly interbedded rock types [columns 33-34]. Rock types are limited to those identifiable in the field with a 10x hand lens or in the laboratory with an approximately 30x binocular microscope. Because of the foregoing limitations, the carbonate rock types include those in Dunham's classification (Ham, 1962, p. 108-121). Mud and mudstone of Folk (1954) are included among clastic rock types, although clay and silt fractions may be described when they can be distinguished. No rock types that require the use of thin sections are included; thin section petrography belongs in a specialized subsystem or card class. Only limited metamorphic and igneous rock types are included in this code designed for sedimentary basins.

Use of modifiers for the principal rock types adds flexibility to a rock description and two modifiers [columns 35-38] are permitted. Modifying terms may depend upon textural, structural, mineralogical, or paleontological variables. The rock and modifier terms employ six columns altogether.

Columns 26-32.—As the code is designed for both field and laboratory identification, a need for describing more than one color is recognized, e.g., weathered and fresh rock. After some experimentation with describing colors in rocks, it was determined that one location [column 26] suffices to locate the colors. Next, three columns describe adequately any color including a tonal modifier. In all seven columns [columns 26-32] are necessary to characterize color differences of most rocks.

Columns 39-43.—The same philosophy carries over to encode the textural variations. A textural key [column 39] is necessary to describe common distributions of grain-size fractions. Allowance is made to document two grain-size classes [columns 40-41] indicated in the textural key, e.g., the largest and the smallest, two modes, clast and matrix, etc. (table 1). In addition, two columns are reserved to state sorting characteristics [column 42] and grain shape [column 43].

Table 1. Numeric code for describing lithologies: card type 3.

1 CARD TYPE
2 DATA SOURCE
3-5 COUNTY NUMBER (area or region)
6-9 LOCATION NUMBER (well number)
10-13 BASE ELEVATION
14-18 TOP OF INTERVAL
19-23 BASE OF INTERVAL
24 CARD NUMBER OF
25 TOTAL CARDS
26 COLOR KEY
27-32 COLOR
33-34 ROCK TYPE
35-38 ROCK MODIFIER
39 TEXTURE KEY
40-41 GRAIN SIZES
42 SORTING
43 GRAIN SHAPE
44-47 STRUCTURES
48-53 MINERALS
54 CEMENT
55 PERCENT OF FOSSILS
56-61 FOSSILS
62 POROSITY PERCENT
63 PORE SIZE
64-65 POROSITY TYPE
66-67 PERCENT OF REPRESENTATIVE SAMPLE
68-73 LATITUDE (12 punch for S)
74-80 LONGITUDE (12 punch for E)

27-32 COLOR

27(30) SHADE
1. Very dark
2. Dark
3. Moderate
4. Light
5. Very light
6. Vitreous

28(31) MODIFIER
1. Blackish
2. Grayish
3. Brownish
4. Yellowish
5. Orangish
6. Greenish
7. Purplish
8. Bluish
9. Reddish
0. Whitish

29(32) PRIMARY
1. Black
2. Gray
3. Brown
4. Yellow
5. Orange
6. Green
7. Purple
8. Blue
9. Red
0. White

33-34 ROCK TYPE

1. Anhydrite
2. Arkose
3. Bentonite
4. Boundstone
5. Breccia
6. Caliche
7. Chalk
8. Chert
9. Clay
10. Claystone
11. Coal
12. Concretion
13. Coquina
14. Diatomite
15. Dolostone
16. Dolomite rudite
17. Dolomite arenite
18. Dolomite lutite
19. Granite wash
20. Grainstone
21. Grapestone
22. Gravel
23. Greensand
24. Greywacke
25. Gypsum
26. Ironstone
27. Lignite
28. Limestone
29. Limestone rudige
30. Limestone arenite
31. Limestone (lutite)
32. Manganese (sedimentary)
33. Marl
34. Microcoquina
35. Mud
36. Mudstone
37. Novaculite
38. Oolite
39. Packstone
40. Peat
41. Pelletstone
42. Phosphorite
43. Pisolite
44. Radioactive bed
45. Salt
46. Sand
47. Sandstone
48. Shale
49. Shell
50. Silt
51. Siltstone
52. Soil
53. Spiculite
54. Travertine
55. Underclay
56. Wackestone
57. Acid Dike
58. Acid Lava
59. Acid Pluton
60. Acid Tuff
61. Basic Dike
62. Basic Lava
63. Basic Pluton
64. Basic Tuff
65. Gneiss
66. Marble
67. Phyllite
68. Quartzite
69. Schist
70. Slate
71. Interbedded anhydrite, salt, and shale
72. Interbedded anhydrite and salt
73. Interbedded anhydrite and shale
74. Interbedded sandstone and shale
75. Interbedded limestone and shale
76. Interbedded dolomite and shale
77. Interbedded limestone and dolomite
78. Interbedded limestone and chert
79. Interbedded dolomite and chert
80. Interbedded anhydrite and dolomite
81. Interbedded anhydrite and limestone
82. Unworkable sample
83. Sample missing (cuttings)
84. No recovery (core)
85. Dismicrite

1 CARD TYPE
1. Location
2. Stratigraphic tops
3. Lithology: sedimentary basins
4. Lithology: Metamorphic-igneous complex
5. Fluids
6. Economic minerals
7. Chemistry
8. Water well data
9. Fractures
0.

2 DATA SOURCE
1. Outcrop
2. Boring—core
3. Boring—cuttings
4. Boring—electrical log
5. Boring—gamma log
6. Boring—driller's log
7. Quarry—open pit
8.
9.
0.

26 COLOR KEY
1. Predominant color only
2. Two grades of color describe lithology (e.g., white to tan limestone)
3. Two different colors for lithology (e.g., red and gray shale), usually laminations
4. Two colors as mottling or burrowing: first color is matrix and second color is burrow or spot
5. Two colors in clastic rock: first color is matrix and second is clasts
6. Weathered rock: first color is weathered surface and second color is fresh surface
7. Three colors—only two dominant
8. Vitreous—transparent
9.
0.

35-38 ROCK MODIFIER

1. Algal
2. Anhydrite
3. Aphanitic
4. Argillaceous
5. Arkosic
6. Basic
7. Birdseye
8. Bioturbated
9. Bored
10. Brecciated
11. Burrowed
12. Calcareous-calcitic
13. Carbonaceous
14. Chalky
15. Cherty
16. Clayey
17. Coarse
18. Concretionary
19. Conglomeratic
20. Convoluted
21. Coralline
22. Crossbedded
23. Detrital
24. Diatomaceous
25. Dolomitic
26. Dolomitic (euhedral)
27. Dolomitic (subhedral)
28. Feldspathic
29. Ferruginous
30. Fine
31. Fossiliferous
32. Fractured
33. Fracture (vein) filled
34. Fragmental
35. Friable
36. Fucoidal
37. Glauconitic
38. Gypsiferous
39. Imbricated
40. Intraclastic
41. Intraformational
42. Lignitic
43. Manganous
44. Micaceous
45. Micritic
46. Mud clasts
47. Muddy
48. Nodular
49. Oolitic
50. Pebbly
51. Pelletal
52. Phosphatic
53. Pillow
54. Pisolitic
55. Porphyritic
56. Porphyroblastic
57. Pyritic
58. Quartzose
59. Reworked
60. Rippled
61. Salty
62. Sandy
63. Shaly
64. Sideritic
65. Siliceous
66. Silty
67. Sparry
68. Spiculitic
69. Stylolitic
70. Sucrose
71. Tripolitic
72. Tuffaceous
73. Vesicular
74. Vitreous
75. Vuggy
76. Waxy
77. Recrystallized
78. Foliated
79. Dull grains
80. Frosted grains
81. Polished grains
82. Loose
83. Friable
84. Consolidated
85. Tough
86. Cemented
87. Crystalline

39 TEXTURE KEY
1. Average grain size in first block only
2. Range of particles—largest size in first block and smallest grain size second
3. Bimodal—size representative of coarse mode first and size of fine mode second
4. Porphyritic and porphyroblastic—size representative of large phenocrysts and size representative of finer matrix
*5. Intraclastic—size representative of clasts and size representative of matrix second
*6. Bioclastic—size representative of fossil clasts and size representative of matrix second
7. Three significant fractions—largest and smallest noted
8. Recrystallized; original texture obscured; size(s) of individual replacement crystals in following blocks
9. Clastic undifferentiated (fossil and intraclasts)—size representative and clasts first and size representative and matrix second
0.

*See 40-41 Grain Size list for notation of micrite and spar.

40-41 GRAIN SIZES
1. Cobble (64 mm)
2. Pebble (64-4 mm)
3. Granule (4-2 mm)
4. Very coarse-grained sand (2-1 mm)
5. Coarse-grained sand (1-0.5 mm)
6. Medium-grained sand (0.5-0.3 mm)
7. Fine-grained sand (0.3-0.13 mm)
8. Very fine-grained sand (0.13-0.06 mm) = sparry calcite
9. Silt (0.06-0.002 mm) or mud
0. Clay = micrite

Table 1 (continued)—

42 SORTING
1. Well
2. Moderately well
3. Poorly—bimodal
4. Poorly—large kurtosis
5. Poorly—moderate kurtosis
6. Poorly—skewed coarse—large kurtosis
7. Poorly—skewed coarse
8. Poorly—skewed fine—large kurtosis
9. Poorly—skewed fine
0. Uniform grain size

43 GRAIN SHAPE
1. Rounded
2. Subrounded
3. Subangular
4. Angular
5. Rounded and broken
6. Subrounded and broken
7. Whole shells
8. Disarticulated valves
9. Broken shells
0. Rounded shell fragments

54 CEMENT
1. Silica
2. Calcite
3. Iron oxide
4. Clay
5. Opal
6. Dolomite
7. Siderite
8. Gypsum-anhydrite
9.
0.

55 PERCENTAGE OF FOSSILS
1. 1-10
2. 11-20
3. 21-30
4. 31-40
5. 41-50
6. 51-60
7. 61-70
8. 71-80
9. 81-90
0. 91-100

44-47 STRUCTURES
1. Convoluted bedding
2. Fissile bedding
3. Flaser bedding
4. Graded bedding
5. Incipient nodular bedding
6. Laminated bedding
7. Lenticular bedding
8. Massive bedding
9. Nodular bedding
10. Pinch and swell bedding
11. Uniform bedding
12. Convex upward crossbedding
13. Festoon crossbedding
14. Planar crossbedding
15. Tabular crossbedding
16. Asymmetrical ripple bedding
17. Climbing ripple bedding
18. Current ripple bedding
19. Cuspate ripple bedding
20. Interference ripple bedding
21. Linguloid ripple bedding
22. Oscillatory ripple bedding
23. Symmetrical ripple bedding
24. Armored mudballs
25. Amygdules
26. Ball and pillow
27. Borings
28. Boudinage
29. Burrows
30. Drag groove casts
31. Flute casts
32. Load casts
33. Prod casts
34. Raindrop casts
35. Rill casts
36. Imbricated clasts
37. Mud clasts
38. Rip-up clasts
39. Clastic dikes
40. Cone-in-cone
41. Convoluted laminations
42. Current crescents
43. Decollement
44. Diapirs
45. Enterolithic folding
46. Geodes
47. Horst and graben microfaulting
48. Lebenssperun
49. Liesegang rings
50. Clast—lineation
51. Fossil—lineation
52. Parting—lineation
53. Mud cracks
54. Scour and fill
55. Slump flow
56. Stylolites
57. Trails
58. Vesicules
59. Vugs
60. Platy
61. Fractured
62. Jointed
63. Veined
64. Pellets (after AGI definition; pellet-shaped intraclasts and Folk)
65. Oolites
66.
67.
68.
69.
70.

56-61 FOSSILS
1. Algae
2. Algae—coralline
3. Algae—cryptozoan
4. Algae—mats
5. Algae—pellets
6. Algae—platy
7. Barnacles
8. Brachiopods
9. Brachiopods—Atremates
10. Brachiopods—Neotremates
11. Brachiopods—Impunctate
12. Brachiopods—Psueopunctate
13. Brachiopods—Punctate
14. Bryozoa
15. Bryozoa—Cyclostomes
16. Bryozoa—Trepostomes
17. Bryozoa—Cryptostomes
18. Bryozoa—Cheilostomes
19. Cephalopods
20. Cephalopods—ammonites
21. Cephalopods—belemnites
22. Charophytes
23. Chitinizoa
24. Conodonts
25. Coprolites
26. Corals
27. Corals—Anthozoans
28. Corals—Tetracorals
29. Corals—Hexacorals
30. Diatoms
31. Echinoderms
32. Echinoderm plates
33. Echinoderm spines
34. Echinoderms—blastoids
35. Echinoderms—crinoids
36. Echinoderms—cystoids
37. Echinoderms—echinoids
38. Fish
39. Fish—scales
40. Fish—teeth
41. Foraminifera
42. Foraminifers—larger
43. Foraminifers—smaller
44. Foraminifers—encrusting
45. Foraminifers—fusulines
46. Fucoids
47. Gastropods
48. Graptolites
49. Ostracods
50. Pelecypods
51. Pelecypods—oysters
52. Plants
53. Plants—leaves
54. Plants—wood
55. Radiolaria
56. Rudistids
57. Scaphopods
58. Sceliodonts
59. Sponges
60. Sponge spicules
61. Sponges—calcisponges
62. Sponges—pliosponges
63. Sponges—silicisponges
64. Spores
65. Stromatoperoids
66. Trails
67. Trilobites
68. Vertebrates
69. Worms
70. Replaced
71. Fragmented

48-53 MINERAL COMPOSITION
1. Actinolite-tremolite
2. Anatase
3. Andalusite
4. Anhydrite
5. Apatite
6. Augite
7. Barite
8. Biotite
9. Brookite
10. Calcite
11. Carbonaceous matter
12. Cassiterite
13. Chert
14. Chlorite
15. Chloritoid
16. Clay minerals
17. Clinozoisite
18. Collophane
19. Cordierite
20. Dolomite
21. Epidote
22. Feldspar
23. Fluorite
24. Garnet
25. Glauconite
26. Gypsum
27. Halloysite
28. Hematite
29. Hornblende
30. Hypersthene-enstatite
31. Illite
32. Ilmenite
33. Kaolinite
34. Kyanite
35. Leucoxene
36. Limonite
37. Magnetite
38. Marcasite
39. Monazite
40. Montmorillonite
41. Muscovite
42. Olivine
43. Pyrite
44. Quartz
45. Rutile
46. Serpentine
47. Siderite
48. Sillimanite
49. Sphene
50. Spinel
51. Staurolite
52. Topaz
53. Tourmaline
54. Xenotime
55. Zeolites
56. Zircon
57. Zoisite
58. Halite

62 POROSITY ABUNDANCE
1. 0-5 percent
2. 6-10 percent
3. 11-15 percent
4. 16-20 percent
5. 21-25 percent
6. 26-30 percent
7. 31-35 percent
8. 36-40 percent
9. 41-45 percent
0. more than 45 percent

63 MEAN PORE SIZE

1.	Micropore	60
2.	Small mesopore	60 - 500
3.	Large mesopore	500 - 4 mm
4.	Small megapore	4 - 32 mm
5.	Large megapore	32 mm - 256 mm
6.	Cavernous	256 mm

64-65 MAJOR POROSITY TYPE
1. Tight
2. Boring—primary
3. Boring—dissolved
4. Breccia—primary
5. Breccia—solution collapse
6. Burrow—primary
7. Burrow—dissolved
8. Cavern
9. Channel
10. Channel—cemented
11. Channel—mud filled
12. Channel—oxidized
13. Fenestral
14. Fenestral—filled
15. Fenestral—primary
16. Fracture—tectonic
17. Growth framework
18. Growth framework—modified
19. Intercrystal
20. Interparticle
21. Intraparticle
22. Moldic
23. Shelter
24. Shrinkage
25. Vugular

Columns 44-47.—As sedimentary structure has become an important property toward interpreting depositional processes and environments, six spaces [columns 44-47] are reserved for listing as many as three structures. Sedimentary structures are only important in outcrop or core, although the list of structures is open for additions such as shapes of self-potential logs or similar items that might reflect sedimentary structure.

Columns 48-53.—As with sedimentary structures, six stacks [columns 48-53] are employed to note a maximum of three rock-forming minerals. Minerals are encoded only where they appear diagnostic of the rock history—deposition, diagenesis, lithification, replacement, or the like. The 11th row can be used to indicate euhedral and the 12th row to indicate subhedral. Cementing minerals of sedimentary rocks is best identified as a single item [column 54]. An obvious cement, such as calcite in limestone, should not be encoded. Specialized minerals like ore minerals or gem minerals belong to another card class or subsystem.

Columns 55-61.—Seven columns are reserved to list the fossil occurring in each interval or sample. One [column 55] notes the percent of fossils in the rock in units of 10 percent (table 1). Any one type of fossil requires two columns and six [columns 56-61] are reserved to list three kinds of fossils. The list of fossils is heterogeneous in that it is possible to note whole forms or even parts. For example, either sponges or sponge spicules and either plants or plant leaves or plant wood are identifiable. In those rocks in which fossils dominate the composition and especially where fossils are invertebrates with hard parts, it may be advisable to employ descriptors like whole shell, broken shell, and disarticulated valves which are listed as grain shape [column 43].

Columns 62-65.—Finally, four columns are reserved to describe the pore space. One [column 62] is designed to give the amount of porosity in increments of 5 percent up to 45 percent. The next [column 63] describes the mean pore size. The following two columns [columns 64-65] describe the major porosity type including primary and secondary porosities. Terminology used to define mean pore size and major porosity type is that of Choquette and Pray (1970). In logging cuttings, we have used the 11th row of column 64 to identify oil shows.

In the numeric code (table 1) many descriptors of rocks are open-ended and other geologists can add terms to the code as they are needed. Categories that can be expended include rock type, rock modifier, structures, mineral composition, fossils, and even porosity type.

USING AND APPLYING THE CODE

ENCODING PROCEDURE

Numeric rock descriptions were pencilled onto a standard printed tablet of 80 columns and 25 rows for later transfer to punched cards. The 11 punch or row was symbolized by drawing a circle around the appropriate coded numeral; the 12 punch was noted by drawing a square. For example, euhedral pyrite was encoded as number 43 in columns 48-49 and then encircled (table 1). Accuracy and speed of encoding was greatly improved by constructing an abbreviated template which was used in conjunction with the encoding tablet (fig. 1). It is surprising how rapidly the numbers of the commonly appearing rock, textures, structures, minerals, fossils, and porosities become memorized with use.

The flexibility and accuracy of the code was first tested by encoding written descriptions of

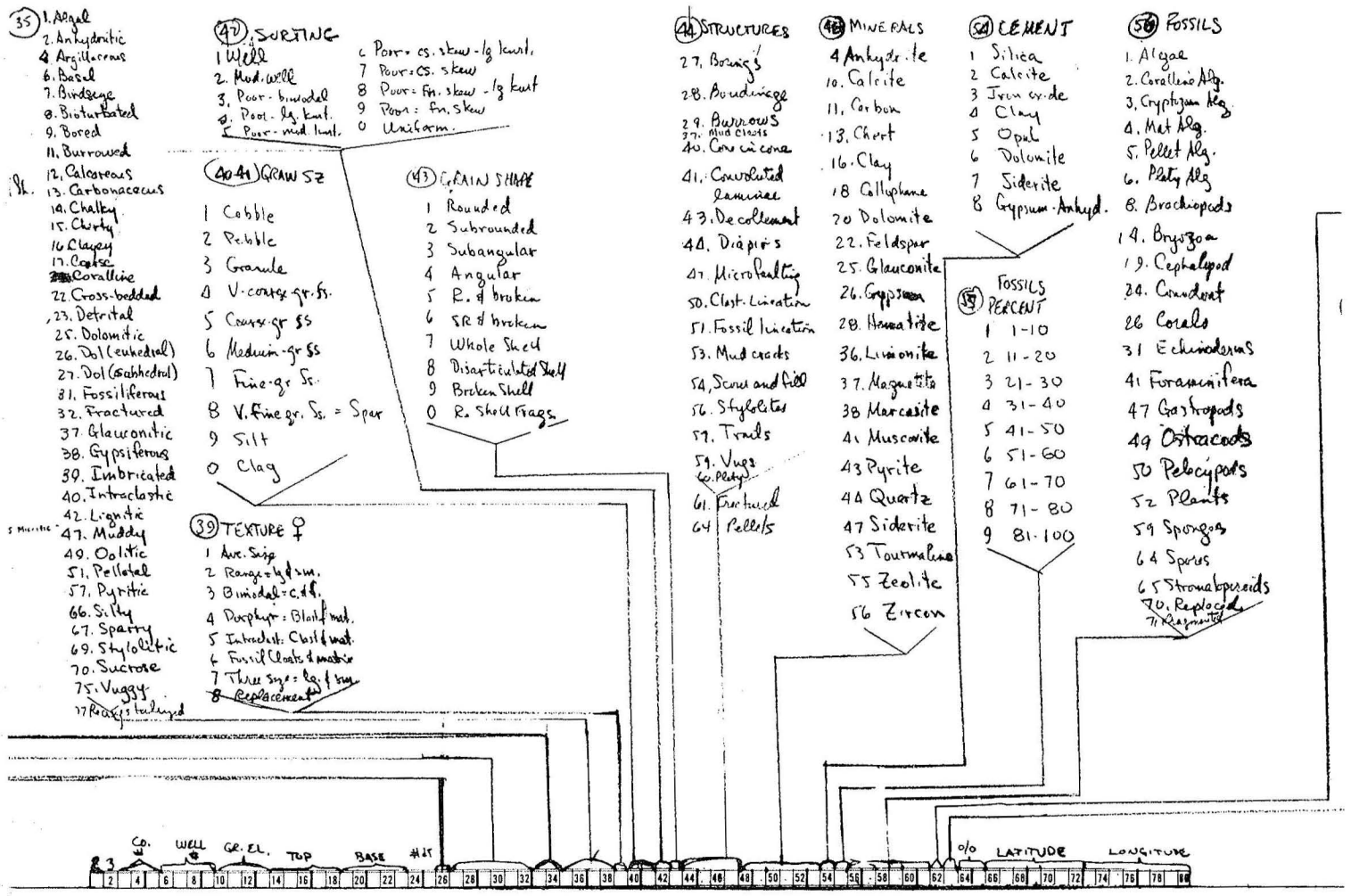

Figure 1. A part of an abbreviated template constructed for encoding lithologies from a local area.

rocks. Data were obtained principally from field notebooks in which rocks of varied sedimentary terranes and of different ages had been described. Next, written descriptions of published measured sections were encoded. Measured sections of various geologists and different times of publication were tested. Instances occurred where other geologists did not remark on all the descriptors of the code or where they listed more structures, minerals, or fossils than space allowed in the code. An arbitrary decision had to be made that the first appearing properties in rock descriptions were most significant and the first appearances were preferentially encoded. In all, no great difficulty was encountered in the encoding of written descriptions of sedimentary rocks known to crop out in a large variety of circumstances.

Following the encoding of written descriptions, hand specimens of many rock types were encoded directly from hand lens identification. The encoding system is too cumbersome for describing outcrops directly in the field, but then, the numeric code was never intended or designed for that use. However, it was designed toward describing rocks directly from exploration and production borings, and we encoded distinct lithologic intervals in more than 4,000 feet of core and more than 24,000 feet of cuttings. A binocular microscope and staining techniques were employed in the laboratory description of subsurface samples. Although many of the samples were carbonates, we also encoded differing conglomerates, sandstones, mudstones, and evaporites from sedimentary basins having varied facies and ages. No major problems were encountered in building a library of coded columnar sections except that the above testing led to minor modifications and additions to the code.

In addition to describing rock samples collected from the subsurface, we examined the problem of encoding the lithic interpretation from standard subsurface logs. These included driller's logs, electric logs, and radioactive logs, some of which were made by sample service companies. Encoding the driller and company service logs entailed the same decisions as were made to symbolize rock descriptions in field notebooks and published measured sections. The amount of descriptive data varied considerably. In older driller's logs there may be as little information as "hard sandstone" given, whereas in the modern logs of ditch samples as described by service companies, the rock descriptions are very detailed.

Encoding mechanical logs poses another problem. There is minimal lithologic information and a rock description from electric or radioactivity logs is clearly an interpretation. However, so long as the source of the data (column 2 in table 1) is recognized, a proper evaluation of the use of the data is possible.

APPLICATIONS

Computer applications of the numeric encoding of vertical lithologic sections are many and can be summarized as lists, graphs, and maps. With continued data collection, the code can be employed to compute solutions for a broad spectrum of geological and environmental problems related to correlation, interpretation, and map construction.

Only results of constructing one kind of list and one graphic display useful in stratigraphic correlation are shown in this circular. Although the code is the important item herein, it seems appropriate to show at least two examples from computer manipulation of the numeric code.

All the examples come from one well. For comparative purposes a classical strip log for logging ditch samples or cuttings of an exploration borehole is shown in figure 2. One example of a list of the abbreviated lithologies is shown for a selected interval of that log (fig. 3). Table 2 shows the abbreviations selected for the color, lithologies, textures, structures, minerals, fossils, and porosity types in the numeric code. This lithologic encoding system readily lends itself to the programming of a lithologic listing (appendix A) as well as many other kinds of lists. It is possible to search one or more boreholes for a tabulation of all the rock types occurring therein. For example, a statistical list of lithologic frequency can be compiled.

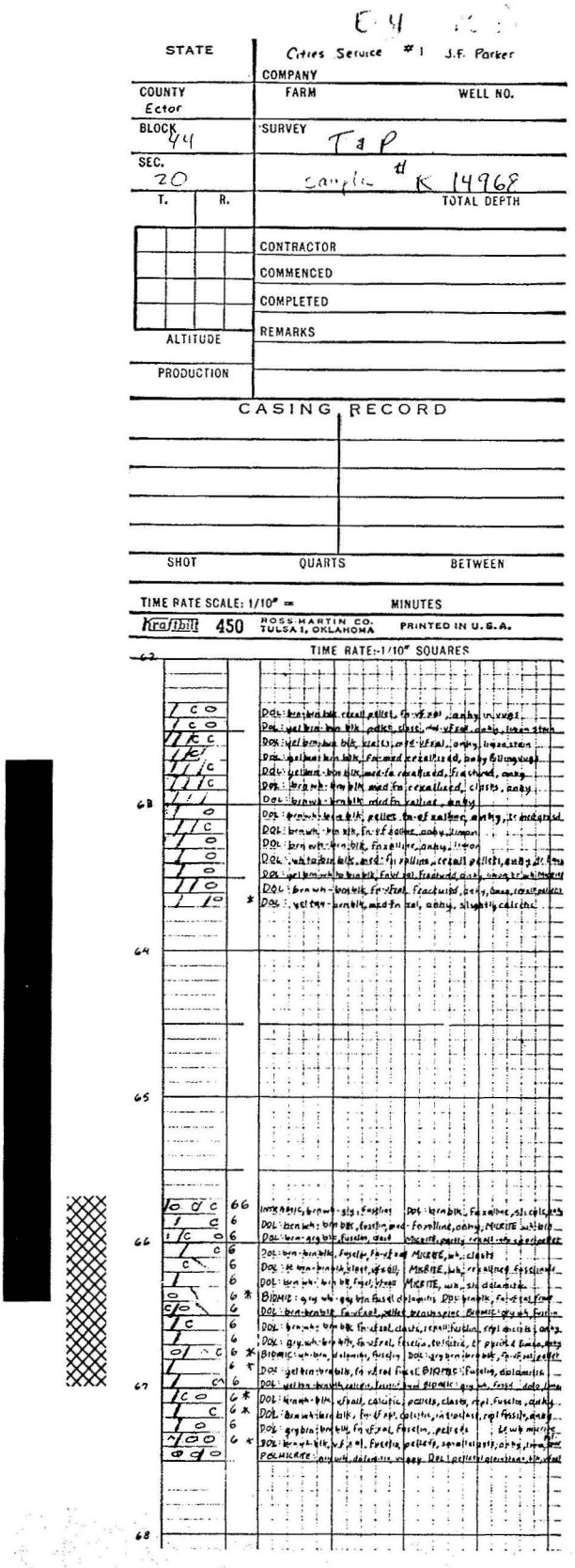

Figure 2. Standard log of ditch cuttings showing depths illustrated in figures 3 and 4.

```
6270  6280  10
GRAD MD YL BR DK BR BK DLAR RXTL FRAC XT MGS FGS UNIGR      MUDCL FRACT      ANHY                                    XTL CRY   99
6280  6290  10
GRAD LT YL BR DK BR BK DLAR RXTL ICL  IC CGS FGS MOD W      MUDCL FRACT      ANHY                                    XTL CRY   99
6290  6300  10
GRAD LT BR WH DK BR BK DLAR RXTL      XT MGS FGS UNIGR      FRACT            ANHY LIM                                XTL CRY   99
6300  6310  10
GRAD LT BR WH DK BR BK DLAR RXTL PEL  IC CGS SPR MOD W R    PELL             ANHY                                    XTL CRY   99
6310  6320  10
GRAD LT BR WH DK BR BK DLAR RXTL      XT MGS FGS UNIGR      FRACT MUDCL      ANHY LIM                                XTL CRY   99
6320  6330  10
GRAD LT BR WH DK BR BK DLAR RXTL      XT MGS     UNIGR      FRACT PELL       ANHY LIM                                XTL CRY   99
6330  6340  10
GRAD LT BR WH MD BR BK DLAR RXTL      XT MGS FGS UNIGR      PELL  FRACT      ANHY LIM                                XTL CRY   99
6340  6350  10
GRAD LT YL BR MD BR BK DLAR RXTL      XT FGS SPR UNIGR      FRACT            ANHY LIM                                XTL       98
6342  6350  10
PRED VL    BK           LSLT MICR     AV MIC     UNIGR                                 CAL                           CEM        2
6350  6360  10
GRAD LT BR WH MD BR BK DLAR RXTL      XT FGS SPR UNIGR      FRACT            ANHY                                    XTL CRY   99
6360  6370  10
GRAD LT YL BR MD BR BK DLAR RXTL      XT MGS FGS UNIGR      FRACT            ANHY                                    XTL CRY H 99
6570  6580  10
PRED DK BR BK           DLAR RXTL CALC XT FGS     UNIGR      VUGS  PELL      CAL  ANHY                              XTL CRY   40
6570  6580  10
GRAD LT BR WH DK BR BK LSAR ICL  FOSS RU CGS FGS MOD W SR   RIPUP FRACT      DOL       CAL X        FORFU              CEM       60
6580  6590  10
GRAD LT BR WH DK BR BK DLAR FOSS RXTL XT MGS FGS UNIGR                        CAL  ANHY     X        FORFU              XTL CRY   80
6580  6590  10
PRED LT BR WH           LSLT FRAC     AV MIC     PSKFI      FRACT                      CAL                           CEM CLK   20
6590  6600  10
GRAD LT    WH LT YL BR LSLT RXTL ICL  IC FGS MIC MOD W SR   MUDCL            LIM       CAL                           CEM       40
6590  6600  10
GRAD DK    BR VD GR BK DLAR ICL  FOSS IC MGS SPR       SR   MUDCL            CAL  ANHY     X        FORFU              XTL CRY   60
6600  6610  10
GRAD MD    BR DK GR BK DLAR FOSS RXTL BI MGS FGS WELL  WHSH FOSLN            CAL  ANHY CAL XX      FORFU RXLL         CEM       70
6600  6610  10
GRAD LT BR WH VL    WH LSLT ICL  RXTL IC MGS MIC       SR   CLLIN                      CAL                           XTL       30
6610  6620  10
PRED LT BR WH           LSLT FOSS RXTL XT MIC                                        CAL X        FORFU CEM          CON       40
6610  6620  10
GRAD LT BR WH DK BR BK DLAR ICL  STY  IC MGS SPR       SA   STY              CAL  LIM                                XTL CRY   99
6620  6630  10
PRED LT BR WH           LSLT DOLS RXTL AV MIC                                DOL  LIM                                TUF       20
6620  6630  10
GRAD LT BR WH DK BR BK DLAR FOSS RXTL XT SPR                                 CAL  ANHY CAL X      FORFU RXLL         XTL CRY   80
6630  6640  10
GRAD LT GR WH MD GR BR LSAR FOSS DOLS BI MGS CL        WHSH FOSLN           DOL       CAL X        FORFU RXLL         CEM       50
6630  6640  10
PRED DK BR BK           DLAR FRAC FOSS XT FGS SPR                 FRACT PELL CAL          X        RXLL               XTL CRY H 50
6640  6650  10
```

Figure 3. Abbreviated printout of lithologies described from ditch cuttings of an exploration borehole.

Table 2. Abbreviations for printout of rock descriptions (from table 1).

COLOR KEY

Column 26

1	PRED
2	GRAD
3	DIFF
4	MTBR
5	CLST
6	WEAT
7	THRE
8	VITR

COLORS

Column 27	28 (31)	29 (32)
1 VD	1 BK	1 BK
2 DK	2 GR	2 GR
3 MD	3 BR	3 BR
4 LT	4 YL	4 YL
5 VL	5 OR	5 OR
	6 GN	6 GN
	7 PR	7 PR
	8 BL	8 BL
	9 RD	9 RD
	0 WH	0 WH

ROCK TYPE

Columns 33-34

1	ANHY	43	PISO
2	ARK	44	RADB
3	BENT	45	SALT
4	BNST	46	SAND
5	BREC	47	SS
6	CALI	48	SH
7	CHLK	49	SHEL
8	CHRT	50	SILT
9	CLAY	51	SLST
10	CLST	52	SOIL
11	COAL	53	SPIC
12	CONC	54	TRAV
13	COQ	55	UCLY
14	DIAT	56	WKST
15	DLST	57	ADYK
16	DLRU	58	ALAV
17	DLAR	59	APLU
18	DLLT	60	ATUF
19	GRWA	61	BDYK
20	GRST	62	BLAV
21	GPST	63	BPLU
22	GRAV	64	BTUF
23	GRSD	65	GNSS
24	GRWK	66	MARB
25	GYP	67	PHYL
26	IRST	68	QTZT
27	LIG	69	SCHI
28	LS	70	SLAT
29	LSRU	71	ANSS
30	LSAR	72	ANST
31	LSLT	73	ANSH
32	MNRK	74	SSSH
33	MARL	75	LSSH
34	MCOQ	76	DLSH
35	MUD	77	LSDL
36	MDST	78	LSCH
37	NOV	79	DLCH
38	OOL	80	UNWK
39	PKST	81	MISS
40	PEAT	82	ANDL
41	PLLS	83	ANLS
42	PHOS		

ROCK MODIFIER

Columns 35-38

1	ALG	45	MICR
2	ANHY	46	MDCL
3	APH	47	MUD
4	ARG	48	NOD
5	ARK	49	OO
6	BAS	50	PEB
7	BSY	51	PEL
8	TURB	52	PHOS
9	BUR	53	PIL
10	BREC	54	PIS
11	BRRW	55	PRPH
12	CALC	56	PRPH
13	CARB	57	PYR
14	CHLK	58	QTZ
15	CHRT	59	RWK
16	CL	60	RIP
17	CORS	61	SALT
18	CONC	62	SND
19	CONG	63	SH
20	CNVO	64	SID
21	COR	65	SIL
22	XBED	66	SILT
23	DET	67	SPAR
24	DIAT	68	SPIC
25	DOL	69	STY
26	DOLE	70	SUC
27	DOLS	71	TRIP
28	FELD	72	TUFF
29	FER	73	VES
30	FINE	74	VIT
31	FOSS	75	VUG
32	FRAC	76	WAX
33	FRVN	77	RXTL
34	FRAG	78	FOL
35	FRI	79	DLGR
36	FUC	80	FRGR
37	GL	81	PLGR
38	GYP	82	LOUS
39	IMB	83	FRIA
40	ICL	84	CONS
41	IFOR	85	TOGH
42	LIG	86	CEM
43	MN	87	XTL
44	MICA		

TEXTURE KEY

Column 39

1	AV
2	RN
3	BM
4	PR
5	IC
6	BO
7	3
8	XT
9	UN
0	

GRAIN SIZES

Columns 40-41

1	COB
2	PEB
3	GR
4	VCS
5	CGS
6	MGS
7	FGS
8	VFS
9	SIL
0	CL = MIC

SORTING

Column 42

1	WELL
2	MODW
3	PBIM
4	PLKU
5	PMKU
6	SKLK
7	SKCO
8	SFLK
9	SKFI
0	UNGR

GRAIN SHAPE

Column 43

1	R	6	SRBR
2	SR	7	WHSH
3	SA	8	DSSH
4	A	9	BRSH
5	RBR	0	RSH

STRUCTURES

Columns 44-47

1	VOLBD	34	RNDRP
2	FISBD	35	RILL
3	FLSBD	36	IMBRC
4	GRDBD	37	MUDCL
5	CPNOD	38	RIPUP
6	LAMBD	39	CLDYK
7	LENBD	40	CN-CN
8	MASBD	41	VOLLM
9	NODBB	42	CURCR
10	PINSW	43	DECUL
11	UNBD	44	DIAP
12	CUX	45	ENFLD
13	FESX	46	GEOD
14	PLANX	47	HSTGR
15	TABX	48	LEBEN
16	ASRIP	49	LIES
17	CLRIP	50	CLLIN
18	CURIP	51	FOSLN
19	CUSPT	52	PRTLN
20	INTRP	53	CRACK
21	LNGRP	54	SCFIL
22	OSCRP	55	SLUMP
23	SYMRP	56	STY
24	ARMMD	57	TRAIL
25	AMIG	58	VESIC
26	B+P	59	VUGS
27	BOR	60	PLATY
28	BOUDN	61	FRACT
29	BRROW	62	JOINT
30	DRGRV	63	VEIN
31	FLCST	64	PELL
32	LDCST	65	OOL
33	PRDCS		

MINERAL COMPOSITION

Columns 48-53

1	ACT	30	HYPEN
2	ANA	31	ILL
3	AND	32	ILM
4	ANHY	33	KAO
5	AP	34	KYA
6	AUG	35	LEUC
7	BAR	36	LIM
8	BIO	37	MAG
9	BRK	38	MAR
10	CAL	39	MON
11	CARB	40	MONT
12	CAS	41	MUS
13	CHT	42	OL
14	CHL	43	PYR
15	CHLD	44	QTZ
16	CL	45	RUT
17	CLIN	46	SERP
18	COL	47	SID
19	COR	48	SIL
20	DOL	49	SPH
21	EPI	50	SPIN
22	FEL	51	STAU
23	FLU	52	TOP
24	GAR	53	TOUR
25	GLAU	54	XEN
26	GYP	55	ZEO
27	HAL	56	ZIR
28	HEM	57	ZOI
29	HORN	58	HAL

CEMENT

Column 54

1	SIL	6	DOL
2	CAL	7	SID
3	FE	8	GYP
4	CL	9	
5	OPL	0	

FOSSILS

Columns 56-61

1	AL	37	ECHI
2	ALCOR	38	FISH
3	ALCRP	39	SCAL
4	ALMT	40	TEET
5	ALPEL	41	FOR
6	ALPLT	42	FORLG
7	BARN	43	FORSM
8	BRAC	44	FOREN
9	BRACA	45	FORFU
10	BRACN	46	FUC
11	BRACI	47	GAST
12	BRAPS	48	GRP
13	BRAPU	49	OST
14	BRY	50	PEL
15	BRYCY	51	OYST
16	BRYTR	52	PL
17	BRYCR	53	PLLV
18	BRYCH	54	PLWD
19	CEPH	55	RAD
20	AMM	56	RUD
21	BEL	57	SCAP
22	CHAR	58	SCEL
23	CHIT	59	SPO
24	CONO	60	SPSPC
25	COPR	61	SPCAL
26	COR	62	SPPLI
27	CORA	63	SPSIL
28	CORT	64	SPOR
29	CORH	65	STROM
30	DIA	66	TRAIL
31	ECH	67	TRIL
32	ECHPL	68	VERT
33	ECHSP	69	WORM
34	BLAS	70	RXTL
35	CRW	71	FRAG
36	CYST		

MEAN PORE SIZE

Column 63

1	MI
2	SMES
3	LMES
4	SMEG
5	LMEG
6	CAV

MAJOR POROSITY TYPE

1	TT	14	FENF
2	BORP	15	FRP
3	BORD	16	FRT
4	BRP	17	GF
5	BRSC	18	GFM
6	BURP	19	TERX
7	BURD	20	TERP
8	CAV	21	TRAP
9	CH	22	MOLD
10	CHC	23	SHEL
11	CHM	24	SHR
12	CHO	25	VUG
13	FEN		

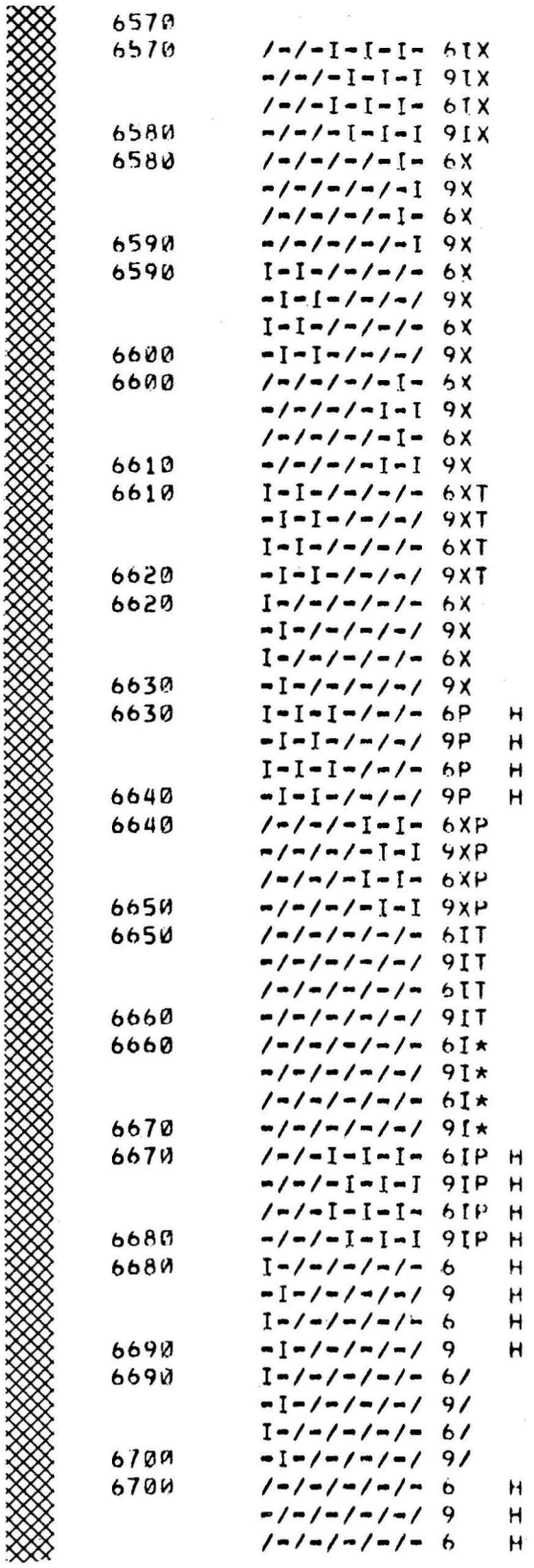

Figure 4. Graphic vertical display of lithologies described from ditch cuttings of an exploration borehole.

Table 3. Printer symbols to simulate graphic vertical logs of borings.

ROCK TYPES		MODIFIERS	
==========		=	ANHYDRITE
==========	ANHYDRITE	<	BORED
==========		≠	BRECCIATED
I-I-I-I-I-		>	BURROWED
-I-I-I-I-I	BOUNDSTONE	I	CALCITIC-CALCAREOUS
I-I-I-I-I-	GRAINSTONE	1	CHALKY
-I-I-I-I-I	GRAPESTONE	^	CHERTY
I-I-I-I-I-	LIMESTONES	-	CLAYEY
-I-I-I-I-I	OOLITE	O	CONGLOMERATIC
I-I-I-I-I-	PACKSTONE	/	DOLOMITIC
-I-I-I-I-I	PELLETSTONE	6	FOSSILIFEROUS
I-I-I-I-I-	TRAVERTINE	G	GLAUCONITIC
-I-I-I-I-I	WACKESTONE	O	GRAVELLY
I-I-I-I-I-		=	GYPSIFEROUS
##########		P	PELLETAL
##########	BRECCIA	*	PYRITIC
##########		X	RECRYSTALLIZED
]-]-]-]-]-		:	SANDY
-]-]-]-]-]	CHALK	-	SHALY
]-]-]-]-]-		†	STYLOLITIC
^^^^^^^^^^		V	VEINED
^^^^^^^^^^	CHERT	H	HYDROCARBON SHOW
^^^^^^^^^^			

----------	CLAY		
----------	CLAYSTONE		
----------	SHALE		
----------	UNDERCLAY		

CCCCCCCCCC			
CCCCCCCCCC	COAL		
CCCCCCCCCC	LIGNITE		
CCCCCCCCCC			
/-/-/-/-/-			
-/-/-/-/-/	DOLOMITES		
/-/-/-/-/-			
0000000000			
0000000000	CONGLOMERATE		
0000000000	GRAVEL		
0000000000			
-:-:-:-:-:			
:-:-:-:-:-	MUD		
-:-:-:-:-:	MUDSTONE		
:-:-:-:-:-	SILT		
-:-:-:-:-:	SILTSTONE		
:-:-:-:-:-			
++++++++++			
++++++++++	SALT		
++++++++++			
::::::::::			
::::::::::	SAND		
::::::::::	SANDSTONE		
::::::::::			
**********			
**********	IGNEOUS		
**********			
##########			
##########	METAMORPHICS		
##########			
	INTERBEDDED		
==========	ANHYDRITE		
I-I-I-I-I-	LIMESTONES		
##########	BRECCIA		
-]-]-]-]-]	CHALK		
^^^^^^^^^^	CHERT		
----------	CLAY ROCKS		
CCCCCCCCCC	COAL ROCKS		
/-/-/-/-/-	DOLOMITES		
0000000000	GRAVEL ROCKS		
:-:-:-:-:-	MUD ROCKS		
::::::::::	SAND ROCKS		
	IN ANY SEQUENCE		

The second example of programming methods is a graphic display of the vertical strip log (fig. 4). The equivalent lithologic intervals in the graphic display and a standard strip log (fig. 2) are illustrated. The possible rock types and modifiers which can be displayed with our present programming are shown in table 3. Where possible, the graphic symbols agree with generally accepted rock symbols of conventional drafting. The program to build graphic displays of vertical lithologic sections is presented in appendix B.

A series of the graphic displays are most useful to construct lithologic cross sections. In the future we plan to experiment with a cross-section program, but it is doubtful that we will employ machine correlation. In addition, we are adapting a fracture mapping program (Cepeda, 1974; Wermund, Cepeda, and Bell, 1974) for lithologic mapping using the numeric encoding system of this circular. However, anyone immediately interested in mapping lithologies from the code can find numerous published programs readily adaptable. For example, the mapping programs in the special computer series published by the State Geological Survey of Kansas are excellent.

CONCLUSIONS

The numeric encoding of lithology for sedimentary basins (1) can be used to describe outcrops, borehole samples, or logs of subsurface rocks; (2) is employable in UTM or longitude-latitude coordinates; (3) utilizes color, texture, structure, minerals, fossils, and porosity to define the rock name; and (4) is useful to program lists, graphs, and maps toward solving problems of stratigraphic mapping for either regional analysis or oil and gas exploration as well as environmental management.

ACKNOWLEDGMENTS

The senior author's earliest experience at formatting lithologic interpretations was gained while working with William A. Jenkins, Jr., at Mobil Research and Development Corporation. In 1963, we first developed a system for the numeric encoding of lithology in 80 columns. The system presented in this paper differs markedly from our earlier work—especially in the descriptions of color, texture, structure, fossils, porosity and location. However, I gratefully acknowledge that many excellent basic concepts developed by Dr. Jenkins are naturally present in much of my work.

Thomas E. Henderson, Department of Computer Sciences, The University of Texas at Austin, wrote the programs shown in the appendix.

Helpful comments were made by D. G. Bebout, C. G. Groat, R. S. Kier, and R. A. Morton, all of whom read the manuscript.

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APPENDIX

APPENDIX A

ABBREVIATED LIST OF LITHOLOGIES

NOTATIONS

Blank Card between Data Sets

		Var ϕ	ϕ	Var I	I
1	Card Type			J1	I1
2	Data Source	LA (J2+1, ½)	A	J2	I1
3-5	County Number	J3	—	J3	I3
6-9	Location Number	J4	—	J4	I4
10-13	Base Elevation	J5	—	J5	I4
14-18	Top of Interval	J6	I5	J6	I5
19-23	Base of Interval	J7	I5	J7	I5
	Width of Interval	KI=J7-J6	I3	—	—
24	Card Number of	—	—	J8	I1
25	Total Cards	—	—	J9	I1
26	Color Key	LB	1A4	J10	I1
27-32	Color	LC & LD	6A2	J11-16	2(I1, 2R1)
33-34	Rock Type	L	A4	J17	I2
35-38	Rock Modifier	LF	2A4	J18-19	2I2
39	Texture Key	LG	A2	J20	I1
40-41	Grain Sizes	LH	2A3	J21-22	2R1
42	Sorting	LI	A5	J23	R1
43	Grain Shape	LJ	A4	J24	R1
44-47	Structures	LK	2A5	J25-26	2I2
48-53	Minerals	LL	3A4	J27-29	3I2
54	Cement	LM	A3	J30	I1
55	Percent of Fossils	LN	I9 (histo)	J31	I1
56-61	Fossils	Lϕ	3A5	J32-34	3I2
62	Induration	LP	A3	J35	I1
63	Porosity	LQ	A3	J36	R1
	Hydrocarbon Stain (K2=30, 1)	LR	A1	K2	
64-65	Percent of Representative Sample	J37	I2	J37	I2
66-72	Latitude	title	A7	J38	A7
73-80	Longitude	title	A8	J39	A8

```
      PROGRAM LITH(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
000002  DIMENSION LA(2,7),LAA(14)
000002  COMMON J1,J2,J3,J4,J5,J6,J7,J8,J9,J10,J11,J12,J13,J14,J15,J16,J17,
     *J18,J19,J20,J21,J22,J23,J24,J25,J26,J27,J28,J29,J30,J31,J32,J33,
     *J34,J35,J36,J37,J38,J39
000002  DIMENSION J(39),LB(9),LC(6),LD(11),LE(84),LF(79),LG(10),LH(13),
     *LI(11),LJ(11),LK(66),LL(59),LM(9),LN(10),LO(72),LP(7),LQ(9),LR(2)
000002  EQUIVALENCE (J1,J),(LA,LAA)
000002  DATA (LAA(I),I=1,14)/                  10H          ,10H          ,
     *          10HOUTCROP   ,10H          ,10HBORING-COR,10HE          ,
     *          10HBORING-CUT,10HTINGS     ,10HBORING-ELE,10HCT LOG     ,
     *          10HBORING-GAM,10HMA LOG    ,10HBORING-DRI,10HLLERS LOG /
000002  DATA (LB(I),I=1,9)/     10H          ,10HPRED       ,10HGRAD       ,
     *          10HDIFF      ,10HMTBR      ,10HCLST       ,10HWEAT       ,
     *          10HTHRE      ,10HVITR      /
000002  DATA (LC(I),I=1,6)/     10H          ,10HVD         ,10HDK         ,
     *          10HMD        ,10HLT        ,10HVL         /
000002  DATA (LD(I),I=1,11)/    10H          ,10HWH         ,10HBK         ,
     *          10HGR        ,10HBR        ,10HYL         ,10HOR         ,
     *          10HGR        ,10HPR        ,10HBL         ,10HRD         /
000002  DATA (LE(I),I=1,79)/    10H          ,10HANHY       ,10HARKO       ,
     *          10HBENT      ,10HBNST      ,10HBREC       ,10HCALI       ,
     *          10HCHLK      ,10HCHRT      ,10HCLAY       ,10HCLST       ,
     *          10HCOAL      ,10HCONC      ,10HCOQ        ,10HDIAT       ,
     *          10HDLST      ,10HDLRU      ,10HDLAR       ,10HDLLT       ,
     *          10HGRWA      ,10HGRST      ,10HGPST       ,10HGRAV       ,
     *          10HGRSD      ,10HGRWK      ,10HGYPS       ,10HIRST       ,
     *          10HLIG       ,10HLS        ,10HLSRU       ,10HLSAR       ,
     *          10HLSLT      ,10HMNRK      ,10HMARL       ,10HMCOQ       ,
     *          10HMUD       ,10HMDST      ,10HNOVA       ,10HOOL        ,
     *          10HPKST      ,10HPEAT      ,10HPELS       ,10HPHOS       ,
     *          10HPISO      ,10HRADB      ,10HSALT       ,10HSAND       ,
     *          10HSS        ,10HSH        ,10HSHEL       ,10HSILT       ,
     *          10HSLST      ,10HSOIL      ,10HSPIC       ,10HTRAV       ,
     *          10HUCLY      ,10HWKST      ,10HADYK       ,10HALAV       ,
     *          10HAPLU      ,10HATUF      ,10HBDYK       ,10HBLAV       ,
     *          10HBPLU      ,10HBTUF      ,10HGNSS       ,10HMARB       ,
     *          10HPHYL      ,10HQTZT      ,10HSCHI       ,10HSLAT       ,
     *          10HANSS      ,10HANST      ,10HANSH       ,10HSSSH       ,
     *          10HLSSH      ,10HDLSH      ,10HLSDL       ,10HLSCH       /
000002  DATA (LE(I),I=80,84)/   10HDLCH      ,10HUNWK       ,10HMISS       ,
     *          10HANDL      ,10HANLS      /
000002  DATA (LF(I),I=1,79)/    10H          ,10HALG        ,10HANHY       ,
     *          10HAPH       ,10HARG       ,10HARK        ,10HBAS        ,
     *          10HBSY       ,10HTURB      ,10HBOR        ,10HBREC       ,
     *          10HBRRW      ,10HCALC      ,10HCARB       ,10HCHLK       ,
     *          10HCHT       ,10HCL        ,10HCORS       ,10HCONC       ,
     *          10HCONG      ,10HCNVO      ,10HCOR        ,10HXBD        ,
     *          10HDET       ,10HDIAT      ,10HDOL        ,10HDOLE       ,
     *          10HDOLS      ,10HFELD      ,10HFER        ,10HFINE       ,
     *          10HFOSS      ,10HFRAC      ,10HFRVN       ,10HFRAG       ,
     *          10HFRI       ,10HFUC       ,10HGL         ,10HGYP        ,
     *          10HIMB       ,10HICL       ,10HIFOR       ,10HLIG        ,
     *          10HMN        ,10HMICA      ,10HMICR       ,10HMDCL       ,
     *          10HMUD       ,10HNOD       ,10HOO         ,10HPEB        ,
     *          10HPEL       ,10HPHOS      ,10HPIL        ,10HPIS        ,
     *          10HPRPH      ,10HPRPH      ,10HPYR        ,10HQTZ        ,
     *          10HRWRK      ,10HPIP       ,10HSALT       ,10HSND        ,
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     *           10HSH       ,10HSID      ,10HSIL      ,10HSILT     ,
     *           10HSPAR     ,10HSPIC     ,10HSTY      ,10HSUC      ,
     *           10HTRIP     ,10HTUFF     ,10HVES      ,10HVIT      ,
     *           10HVUG      ,10HWAX      ,10HRXTL     ,10HFOL      /
000002        DATA (LG(I),I=1,10)/  10H     ,10HAV       ,10HRU       ,
     *           10HBI       ,10HPR       ,10HIC       ,10HBI       ,
     *           10H3        ,10HXT       ,10HUN       /
000002        DATA (LH(I),I=1,13)/  10H     ,10HCL       ,10HCOB      ,
     *           10HPEB      ,10HGR       ,10HVCS      ,10HCGS      ,
     *           10HMGS      ,10HFGS      ,10HVFS      ,10HSIL      ,
     *           10HMIC      ,10HSPR      /
000002        DATA (LI(I),I=1,11)/  10H     ,10HUNIGR    ,10HWELL     ,
     *           10HMOD W    ,10HPOBIM    ,10HPLKUR    ,10HPMOKU    ,
     *           10HPSCLK    ,10HPSKCO    ,10HPSFLK    ,10HPSKFI    /
000002        DATA (LJ(I),I=1,11)/  10H     ,10HR SH     ,10HR        ,
     *           10HSR       ,10HSA       ,10H         ,10HRBR      ,
     *           10HSRBR     ,10HWHSH     ,10HDSSH     ,10HBRSH     /
000002        DATA (LK(I),I=1,66)/  10H     ,10HVOLBD    ,10HFISBD    ,
     *           10HFLSBD    ,10HGRDBD    ,10HCPNOD    ,10HLAMBD    ,
     *           10HLENBD    ,10HMASBD    ,10HNODBD    ,10HPINSW    ,
     *           10HUNBD     ,10HCVXBD    ,10HFESX     ,10HPLANX    ,
     *           10HTABX     ,10HASRIP    ,10HCLRIP    ,10HCURIP    ,
     *           10HCUSPT    ,10HINTRP    ,10HLNGRP    ,10HOSCRP    ,
     *           10HSYMRP    ,10HARMMD    ,10HAMIG     ,10HB+P      ,
     *           10HBOR      ,10HBOUDN    ,10HBROW     ,10HDRGRV    ,
     *           10HFLCST    ,10HLDCST    ,10HPRDCS    ,10HRNDRP    ,
     *           10HRILL     ,10HIMBRC    ,10HMUDCL    ,10HRIPUP    ,
     *           10HCLDYK    ,10HCN-CN    ,10HVOLLM    ,10HCURCR    ,
     *           10HDECOL    ,10HDIAP     ,10HENFLD    ,10HGEOD     ,
     *           10HHSTGR    ,10HLEBEN    ,10HLIESR    ,10HCLLIN    ,
     *           10HFOSLN    ,10HPRTLN    ,10HCRACK    ,10HSCFIL    ,
     *           10HSLUMP    ,10HSTY      ,10HTRAIL    ,10HVESI     ,
     *           10HVUGS     ,10HPLATY    ,10HFRACT    ,10HJOINT    ,
     *           10HVEIN     ,10HPELL     ,10HOOLI     /
000002        DATA (LL(I),I=1,59)/  10H     ,10HACT      ,10HANA      ,
     *           10HAND      ,10HANHY     ,10HAP       ,10HAUG      ,
     *           10HBAR      ,10HBIO      ,10HBRK      ,10HCAL      ,
     *           10HCARB     ,10HCAS      ,10HCHT      ,10HCHL      ,
     *           10HCHLD     ,10HCL       ,10HCLIN     ,10HCOL      ,
     *           10HCOR      ,10HDOL      ,10HEPI      ,10HFELD     ,
     *           10HFLU      ,10HGAR      ,10HGLAU     ,10HGYP      ,
     *           10HHAL      ,10HHEM      ,10HHORN     ,10HHYPE     ,
     *           10HILL      ,10HILM      ,10HKAO      ,10HKYA      ,
     *           10HLEUC     ,10HLIM      ,10HMAG      ,10HMAR      ,
     *           10HMON      ,10HMONT     ,10HMUS      ,10HOL       ,
     *           10HPYR      ,10HQTZ      ,10HRUT      ,10HSERP     ,
     *           10HSID      ,10HSILL     ,10HSPH      ,10HSPIN     ,
     *           10HSTAU     ,10HTOP      ,10HTOUR     ,10HXEN      ,
     *           10HZEOL     ,10HZIR      ,10HZOIS     ,10HHAL      /
000002        DATA (LM(I),I=1,9)/   10H     ,10HSIL      ,10HCAL      ,
     *           10HFE       ,10HCL       ,10HOPL      ,10HDOL      ,
     *           10HSID      ,10HSYP      /
000002        DATA (LN(I),I=1,10)/  10H     ,10HX        ,10HXX       ,
     *           10HXXX      ,10HXXXX     ,10HXXXXX    ,10HXXXXXX   ,
     *           10HXXXXXXX  ,10HXXXXXXXX ,10HXXXXXXXXX /
000002        DATA (LO(I),I=1,72)/  10H     ,10HAL       ,10HALCOR    ,
     *           10HALCRP    ,10HALMT     ,10HALPEL    ,10HALPLT    ,
     *           10HBARN     ,10HBRAC     ,10HBRACA    ,10HBRACN    ,
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     *           10HBRACI     ,10HBRAPS     ,10HBRAPU     ,10HBRY       ,
     *           10HBRYCY     ,10HBRYTR     ,10HBRYCR     ,10HBRYCH     ,
     *           10HCEPH      ,10HAMMO      ,10HBEL       ,10HCHAR      ,
     *           10HCHIT      ,10HCONO      ,10HCOPRO     ,10HCO        ,
     *           10HCOR A     ,10HCOR T     ,10HCOR H     ,10HDIAT      ,
     *           10HECH       ,10HECHPL     ,10HECHSP     ,10HBLAS      ,
     *           10HCRIN      ,10HCYS       ,10HECHIN     ,10HFISH      ,
     *           10HSCAL      ,10HTEETH     ,10HFOR       ,10HFORLG     ,
     *           10HFORSM     ,10HFOREN     ,10HFORFU     ,10HFUC       ,
     *           10HGAST      ,10HGRAP      ,10HOSTR      ,10HPEL       ,
     *           10HOYST      ,10HPL        ,10HPL LV     ,10HPL WD     ,
     *           10HRAD       ,10HRUD       ,10HSCAP      ,10HSCEL      ,
     *           10HSP        ,10HSPSPC     ,10HSPCAL     ,10HSPPLI     ,
     *           10HSPSIL     ,10HSPOR      ,10HSTROM     ,10HTRAIL     ,
     *           10HTRIL      ,10HVERT      ,10HWORM      ,10HRXLL      ,
     *           10HFRAG      /
000002          DATA (LP(I),I=1,7)/      10H           ,10HLSE       ,10HFRI       ,
     *           10HCON       ,10HTUF       ,10HCEM       ,10HXTL       /
000002          DATA (LQ(I),I=1,9)/      10H           ,10HCLK       ,10HFRA       ,
     *           10HCRY       ,10HGRA       ,10HMOL       ,10HSOL       ,
     *           10HVUG       ,10HTT        /
000002          DATA (LR(I),I=1,2)/      10H           ,10HH         /
000002    5     KS=1
000003    6     READ 102,(J(I),I=1,39)
000011    102   FORMAT(2I1,I3,2I4,2I5,3I1,2(I1,2R1),3I2,I1,4R1,5I2,2I1,3I2,I1,R1,I
     *2,A7,A8)
000011          IF(EOF,5) 10,20
000014    10    STOP
000016    20    IF(J1) 25,5
000017    25    IF(J1.EQ.2) GO TO 26
000021    24    PRINT 103,(J(I),I=1,39)
000027    103   FORMAT(*1THE FOLLOWING CARD IS OF THE WRONG TYPE OR SOURCE TO CONT
     *INUE*/1X,2I1,I3,2I4,2I5,3I1,2(I1,2R1),3I2,I1,4R1,5I2,2I1,3I2,I1,R1
     *,I2,A7,A8)
000027          STOP
000031    26    IF(J2.NE.2.AND.J2.NE.3) GO TO 24
000041          J2=J2+1
000042          K1=J7-J6
000043          J10=J10+1
000045          J11=J11+1
000046          J14=J14+1
000047          J12=J12-25
000050          J13=J13-25
000051          J15=J15-25
000052          J16=J16-25
000053          IF(J12.GT.11) J12=1
000056          IF(J13.GT.11) J13=1
000061          IF(J15.GT.11) J15=1
000064          IF(J16.GT.11) J16=1
000067          J17=J17+1
000071    4     J18=J18+1
000073          J19=J19+1
000074          J20=J20+1
000075          J21=J21-25
000076          J22=J22-25
000077          IF(J21.GT.11) J21=1
000102          IF(J22.GT.11) J22=1
000105          IF(J21.EQ.2.AND.(J17.EQ.16.OR.J17.EQ.19.OR.J17.EQ.29.OR.J17.EQ.32.
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     *OR.J17.EQ.42)) J21=12
000135        IF(J22.EQ.2.AND.(J17.EQ.16.OR.J17.EQ.19.OR.J17.EQ.29.OR.J17.EQ.32.
     *OR.J17.EQ.42)) J22=12
000165        IF(J21.EQ.10.AND.(J17.EQ.16.OR.J17.EQ.18.OR.J17.EQ.29.OR.J17.EQ.31
     *.OR.J17.EQ.5.OR.J17.EQ.21.OR.J17.EQ.22.OR.J17.EQ.40.OR.J17.EQ.57))
     *J21=13
000234        IF(J22.EQ.10.AND.(J17.EQ.16.OR.J17.EQ.18.OR.J17.EQ.29.OR.J17.EQ.31
     *.OR.J17.EQ.5.OR.J17.EQ.21.OR.J17.EQ.22.OR.J17.EQ.40.OR.J17.EQ.57))
     *J22=13
000303        J23=J23-25
000305        IF(J23.GT.11) J23=1
000310        J24=J24-25
000311        IF(J24.GT.11) J24=1
000314        J25=J25+1
000316        J26=J26+1
000317        J27=J27+1
000320        J28=J28+1
000321        J29=J29+1
000322        J30=J30+1
000323        J31=J31+1
000324        J32=J32+1
000325        J33=J33+1
000326        J34=J34+1
000327        J35=J35+1
000330        K2=1
000330        IF(J36.LT.10.OR.J36.EQ.58) K2=2
000341        IF(K2.EQ.1) J36=J36-27
000344        J36=J36+1
000345        IF(J36.GE.10) J36=1
000350        IF(KS.NE.1) GO TO 43
000352        PRINT 104,LA(1,J2),LA(2,J2),J3,J4,J5,J38,J39
000376        KS=0
000377   43   PRINT 105,J6,J7,K1,LB(J10),LC(J11),LD(J12),LD(J13),LC(J14),LD(J15)
     * ,LD(J16),LE(J17),LF(J18),LF(J19),LG(J20),LH(J21),LH(J22),LI(J23),
     *LJ(J24),LK(J25),LK(J26),LL(J27),LL(J28),LL(J29),LM(J30),LN(J31),LO
     *(J32),LO(J33),LO(J34),LP(J35),LQ(J36),LR(K2),J37
000503        GO TO 6
000504   105  FORMAT(2I6,I4,/, 2X,A5,6A3,3A5,A3,2A4,A6,A5,2A6,3A5,A4,A10,3A6,2A4
     *,A2,I2)
000504   104  FORMAT(*1LITHOLOGY FOR  DATA SOURCE = *,2A10,* COUNTY = *,I3,* LOC
     *ATION = *,I4,* BASE ELEVATION = *,I4,* LAT = *,A7,* LONG = *,A8//)
000504        END
000700
```

APPENDIX B

GRAPHIC PRINTOUT OF VERTICAL STRIP LOG

NOTATIONS

I

J1	I1	1 Card Type
J2	I2	2 Data Source
J3	I3	3-5 County Number
J4	I4	6-9 Location Number
J5	I4	10-13 Base Elevation
J6	I5	14-18 Top of Interval
J7	I5	19-23 Base of Interval
J8	I1	24 Card Number
J9	I1	25 Total Cards
7X		26 Color Key
		27-32 Color
J10	I2	33-34 Rock Type
J11-12	2I2	35-38 Rock Modifier
5X		39 Texture Key
		40-41 Grain Sizes
		42 Sorting
		43 Grain Shape
J13-14	2I2	44-47 Structures
J15,16,17	3I2	48-53 Minerals
1X		54 Cement
J18	I1	55 Percent of Fossils
		56-61 Fossils
		62 Induration
J19	R1	63 Porosity
J20	I2	64-65 Percent of Representative Sample
		66-72 Latitude
		73-80 Longitude

PRIMARY (33-34)

SECONDARY (35-38, 44-47, 48-53, and 55)

```
                PROGRAM LITHP(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
000002          COMMON J1,J2,J3,J4,J5,J6,J7,J8,J9,J10,J11,J12,J13,J14,J15,J16,J17,
               *J18,J19,J20,M01A,M02A,M03A,M04A,M05A,M06A,M07A,M08A,M09A,M10A,
               *M11A,M12A,M13A,M14A,M01B,M02B,M03B,M04B,M05B,M06B,M07B,M08B,M09B,
               *M10B,M11B,M12B,M13B,M14B,M01C,M02C,M03C,M04C,M05C,M06C,M07C,
               *M08C,M09C,M10C,M11C,M12C,M13C,M14C
000002          DIMENSION IDES(15,600,3),IA(25),JA(20),IM(3),IDE(14,3),JJ3(3),
               *JJ4(3)
000002          DATA (IA(I),I=1,25)/    10H           ,10HI          -,10H/         -,
               *            10H=         =,10H↑        ↓,10H]         -,10HA         ^,
               *            10H.         .,10H-        -,10HO         0,10H,         -,
               *            10H+         +,10H=        +,10H6         9,10H≤         ≤,
               *            10H≥         ≥,10HI        I,10H/         /,10HG         G,
               *            10HT         T,10HX        X,10HP         P,10HV         V,
               *            10H*         *,10HH        H/
000002          EQUIVALENCE (JA,J1),(M01A,IDE)
000002    4     READ 101,L1,L2,L3,L4
000016    101   FORMAT(I2,2I5,I1)
000016          IF(EOF,5) 10,15
000021    10    STOP
000023    15    L5=(L3-L2)/L1
000030          DO 5 I=1,15
000031          DO 5 J=1,L5
000032          DO 5 K=1,L4
000042    5     IDES(I,J,K)=1
000050          DO 95 KA=1,L4
000052    16    READ 102,(JA(I),I=1,20)
000060    102   FORMAT(2I1,I3,2I4,2I5,2I1,7X,3I2,5X,5I2,1X,I1,7X,R1,I2)
000060          IF(EOF,5) 96,17
000063    17    IF(J1.EQ.0) GO TO 95
000065          JJ3(KA)=J3
000066          JJ4(KA)=J4
000070          K1=(J20+5)/10
000074          K6=(J6-J5-L2+L1*1.5)/L1
000105          K7=(J7-J5-L2+L1*0.5)/L1
000115          K5=2
000116          IF(J10.EQ.4.OR.J10.EQ.20.OR.J10.GE.28.AND.J10.LE.31.OR.J10.EQ.39.O
               *R.J10.EQ.41.OR.J10.EQ.56.OR.J10.EQ.75) GO TO 49
000160          K5=K5+1
000161          IF(J10.EQ.76.OR.J10.GE.15.AND.J10.LE.18) GO TO 49
000175          K5=K5+1
000176          IF(J10.EQ.1.OR.J10.EQ.25) GO TO 49
000205          K5=K5+1
000206          IF(J10.EQ.5) GO TO 49
000210          K5=K5+1
000211          IF(J10.EQ.7) GO TO 49
000212          K5=K5+1
000213          IF(J10.EQ.8) GO TO 49
000215          K5=K5+1
000215          IF(J10.EQ.46.OR.J10.EQ.47.OR.J10.EQ.50.OR.J10.EQ.51) GO TO 49
000234          K5=K5+1
000235          IF(J10.EQ.9.OR.J10.EQ.10.OR.J10.EQ.48) GO TO 49
000250          K5=K5+1
000251          IF(J10.EQ.22) GO TO 49
000253          K5=K5+1
000253          IF(J10.EQ.36) GO TO 49
000255          K5=K5+1
000255          IF(J10.EQ.45) GO TO 49
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000257          K5=K5+1
000260          IF(J10.EQ.72) GO TO 49
000261          K5=1
000262    49    IH=1
000263          IG=1
000264          IM(1)=1
000264          IM(2)=1
000265          IM(3)=1
000265          IF(J19.LT.10.OR.J19.EQ.58) IH=2
000276          IF(J18.EQ.0.AND.J11.NE.31.AND.J12.NE.31) GO TO 50
000307          IM(1)=14
000307          IG=2
000311    50    IF(J11.NE.2.AND.J11.NE.38.AND.J12.NE.2.AND.J12.NE.38) GO TO 51
000330          IM(IG)=4
000332          IG=IG+1
000333    51    IF(J11.NE.9.AND.J12.NE.9.AND.J13.NE.27.AND.J14.NE.27) GO TO 52
000350          IM(IG)=15
000352          IG=IG+1
000353          IF(IG.GT.3) GO TO 18
000356    52    IF(J11.NE.10.AND.J12.NE.10) GO TO 53
000365          IM(IG)=5
000367          IG=IG+1
000367          IF(IG.GT.3) GO TO 18
000373    53    IF(J11.NE.11.AND.J12.NE.11.AND.J13.NE.29.AND.J14.NE.29) GO TO 54
000410          IM(IG)=16
000412          IG=IG+1
000413          IF(IG.GT.3) GO TO 18
000416    54    IF(J11.NE.12.AND.J12.NE.12) GO TO 55
000425          IM(IG)=17
000427          IG=IG+1
000427          IF(IG.GT.3) GO TO 18
000433    55    IF(J11.NE.15.AND.J12.NE.15.AND.J15.NE.13.AND.J16.NE.13.AND.J17.NE.
               $13) GO TO 56
000457          IM(IG)=7
000461          IG=IG+1
000462          IF(IG.GT.3) GO TO 18
000465    56    IF(J11.NE.16.AND.J12.NE.16.AND.J11.NE.63.AND.J12.NE.63) GO TO 57
000502          IM(IG)=9
000504          IG=IG+1
000505          IF(IG.GT.3) GO TO 18
000510    57    IF(J11.NE.25.AND.J12.NE.25) GO TO 58
000517          IM(IG)=18
000521          IG=IG+1
000521          IF(IG.GT.3) GO TO 18
000525    58    IF(J11.NE.37.AND.J12.NE.37.AND.J15.NE.25.AND.J16.NE.25.AND.J17.NE.
               *25) GO TO 59
000551          IM(IG)=19
000553          IG=IG+1
000554          IF(IG.GT.3) GO TO 18
000557    59    IF(J11.NE.62.AND.J12.NE.62) GO TO 60
000566          IM(IG)=8
000570          IG=IG+1
000570          IF(IG.GT.3) GO TO 18
000574    60    IF(J11.NE.69.AND.J12.NE.69.AND.J13.NE.56.AND.J14.NE.56) GO TO 61
000611          IM(IG)=20
000613          IG=IG+1
000614          IF(IG.GT.3) GO TO 18
000617    61    IF(J11.NE.77.AND.J12.NE.77) GO TO 62
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000626          IM(IG)=21
000630          IG=IG+1
000630          IF(IG.GT.3) GO TO 18
000634    62    IF(J11.NE.51.AND.J12.NE.51.AND.J13.NE.64.AND.J14.NE.64) GO TO 63
000651          IM(IG)=22
000653          IG=IG+1
000654          IF(IG.GT.3) GO TO 18
000657    63    IF(J13.NE.63.AND.J14.NE.63) GO TO 64
000666          IM(IG)=23
000670          IG=IG+1
000670          IF(IG.GT.3) GO TO 18
000674    64    IF(J15.NE.43.AND.J16.NE.43.AND.J17.NE.43) GO TO 18
000706          IM(IG)=24
000710          IG=IG+1
000711    18    IF(K7.LT.K6) GO TO 16
000714          DO 94 KB=K6,K7
000715          IF(K1.EQ.0) GO TO 8
000716          K2=IDES(15,KB,KA)
000722          IF(K2.GE.11) GO TO 8
000725          K4=K2+K1-1
000726          IF(K4.GT.10) K4=10
000732          DO 7 KC=K2,K4
000744    7     IDES(KC,KB,KA)=K5
000746          IDES(15,KB,KA)=K4+1
000753    8     IF(IH.EQ.2) IDES(14,KB,KA)=25
000762          IF(IG.EQ.1) GO TO 94
000764          IGA=IG-1
000765          DO 93 KD=1,IGA
000766          IF(IM(KD).NE.14) GO TO 90
000770          IF(IDES(11,KB,KA).EQ.14) GO TO 93
001006          IDES(13,KB,KA)=IDES(12,KB,KA)
001007          IDES(12,KB,KA)=IDES(11,KB,KA)
001007          IDES(11,KB,KA)=14
001010          GO TO 93
001011    90    IF(IDES(13,KB,KA).NE.1) GO TO 94
001017          DO 89 KE=11,13
001020          IF(IM(KD).EQ.IDES(KE,KB,KA)) GO TO 93
001026          IF(IDES(KE,KB,KA).NE.1) GO TO 89
001033          IDES(KE,KB,KA)=IM(KD)
001037          GO TO 93
001040    89    CONTINUE
001042    93    CONTINUE
001045    94    CONTINUE
001050          GO TO 16
001050    95    CONTINUE
001053    96    PRINT 103,(JJ3(I),JJ4(I),I=1,L4)
001070          PRINT 104
001074    104   FORMAT(*0*)
001074    103   FORMAT(*1*,3(14X,I3,1X,I4,14X),/)
001074          DO 97 KF=1,L5
001076          LB=L2+KF*L1
001100          LT=LB-L1
001102          DO 98 KG=1,L4
001103          DO 98 KH=1,14
001115    98    IDE(KH,KG)=IDES(KH,KF,KG)
001122          GO TO (110,120,130),KG
001130    110   PRINT 111,LT,IA(M01A),IA(M02A),IA(M03A),IA(M04A),IA(M05A),
               *IA(M06A),IA(M07A),IA(M08A),IA(M09A),IA(M10A),IA(M11A),IA(M12A),
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     *IA(M13A),IA(M14A)
001172        PRINT 112,   IA(M01A),IA(M02A),IA(M03A),IA(M04A),IA(M05A),
     *IA(M06A),IA(M07A),IA(M08A),IA(M09A),IA(M10A),IA(M11A),IA(M12A),
     *IA(M13A),IA(M14A)
001232        PRINT 113,   IA(M01A),IA(M02A),IA(M03A),IA(M04A),IA(M05A),
     *IA(M06A),IA(M07A),IA(M08A),IA(M09A),IA(M10A),IA(M11A),IA(M12A),
     *IA(M13A),IA(M14A)
001272        PRINT 114,LB,IA(M01A),IA(M02A),IA(M03A),IA(M04A),IA(M05A),
     *IA(M06A),IA(M07A),IA(M08A),IA(M09A),IA(M10A),IA(M11A),IA(M12A),
     *IA(M13A),IA(M14A)
001334        GO TO 97
001335   120  PRINT 111,LT,IA(M01A),IA(M02A),IA(M03A),IA(M04A),IA(M05A),
     *IA(M06A),IA(M07A),IA(M08A),IA(M09A),IA(M10A),IA(M11A),IA(M12A),
     *IA(M13A),IA(M14A),LT,IA(M01B),IA(M02B),IA(M03B),IA(M04B),IA(M05B),
     *IA(M06B),IA(M07B),IA(M08B),IA(M09B),IA(M10B),IA(M11B),IA(M12B),
     *IA(M13B),IA(M14B)
001435        PRINT 112,   IA(M01A),IA(M02A),IA(M03A),IA(M04A),IA(M05A),
     *IA(M06A),IA(M07A),IA(M08A),IA(M09A),IA(M10A),IA(M11A),IA(M12A),
     *IA(M13A),IA(M14A),   IA(M01B),IA(M02B),IA(M03B),IA(M04B),IA(M05B),
     *IA(M06B),IA(M07B),IA(M08B),IA(M09B),IA(M10B),IA(M11B),IA(M12B),
     *IA(M13B),IA(M14B)
001531        PRINT 113,   IA(M01A),IA(M02A),IA(M03A),IA(M04A),IA(M05A),
     *IA(M06A),IA(M07A),IA(M08A),IA(M09A),IA(M10A),IA(M11A),IA(M12A),
     *IA(M13A),IA(M14A),   IA(M01B),IA(M02B),IA(M03B),IA(M04B),IA(M05B),
     *IA(M06B),IA(M07B),IA(M08B),IA(M09B),IA(M10B),IA(M11B),IA(M12B),
     *IA(M13B),IA(M14B)
001625        PRINT 114,LB,IA(M01A),IA(M02A),IA(M03A),IA(M04A),IA(M05A),
     *IA(M06A),IA(M07A),IA(M08A),IA(M09A),IA(M10A),IA(M11A),IA(M12A),
     *IA(M13A),IA(M14A),LB,IA(M01B),IA(M02B),IA(M03B),IA(M04B),IA(M05B),
     *IA(M06B),IA(M07B),IA(M08B),IA(M09B),IA(M10B),IA(M11B),IA(M12B),
     *IA(M13B),IA(M14B)
001725        GO TO 97
001726   130  PRINT 111,LT,IA(M01A),IA(M02A),IA(M03A),IA(M04A),IA(M05A),
     *IA(M06A),IA(M07A),IA(M08A),IA(M09A),IA(M10A),IA(M11A),IA(M12A),
     *IA(M13A),IA(M14A),LT,IA(M01B),IA(M02B),IA(M03B),IA(M04B),IA(M05B),
     *IA(M06B),IA(M07B),IA(M08B),IA(M09B),IA(M10B),IA(M11B),IA(M12B),
     *IA(M13B),IA(M14B),LT,IA(M01C),IA(M02C),IA(M03C),IA(M04C),IA(M05C),
     *IA(M06C),IA(M07C),IA(M08C),IA(M09C),IA(M10C),IA(M11C),IA(M12C),
     *IA(M13C),IA(M14C)
002064        PRINT 112,   IA(M01A),IA(M02A),IA(M03A),IA(M04A),IA(M05A),
     *IA(M06A),IA(M07A),IA(M08A),IA(M09A),IA(M10A),IA(M11A),IA(M12A),
     *IA(M13A),IA(M14A),   IA(M01B),IA(M02B),IA(M03B),IA(M04B),IA(M05B),
     *IA(M06B),IA(M07B),IA(M08B),IA(M09B),IA(M10B),IA(M11B),IA(M12B),
     *IA(M13B),IA(M14B),   IA(M01C),IA(M02C),IA(M03C),IA(M04C),IA(M05C),
     *IA(M06C),IA(M07C),IA(M08C),IA(M09C),IA(M10C),IA(M11C),IA(M12C),
     *IA(M13C),IA(M14C)
002214        PRINT 113,   IA(M01A),IA(M02A),IA(M03A),IA(M04A),IA(M05A),
     *IA(M06A),IA(M07A),IA(M08A),IA(M09A),IA(M10A),IA(M11A),IA(M12A),
     *IA(M13A),IA(M14A),   IA(M01B),IA(M02B),IA(M03B),IA(M04B),IA(M05B),
     *IA(M06B),IA(M07B),IA(M08B),IA(M09B),IA(M10B),IA(M11B),IA(M12B),
     *IA(M13B),IA(M14B),   IA(M01C),IA(M02C),IA(M03C),IA(M04C),IA(M05C),
     *IA(M06C),IA(M07C),IA(M08C),IA(M09C),IA(M10C),IA(M11C),IA(M12C),
     *IA(M13C),IA(M14C)
002344        PRINT 114,LB,IA(M01A),IA(M02A),IA(M03A),IA(M04A),IA(M05A),
     *IA(M06A),IA(M07A),IA(M08A),IA(M09A),IA(M10A),IA(M11A),IA(M12A),
     *IA(M13A),IA(M14A),LB,IA(M01B),IA(M02B),IA(M03B),IA(M04B),IA(M05B),
     *IA(M06B),IA(M07B),IA(M08B),IA(M09B),IA(M10B),IA(M11B),IA(M12B),
     *IA(M13B),IA(M14B),LB,IA(M01C),IA(M02C),IA(M03C),IA(M04C),IA(M05C),
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                *IA(M06C),IA(M07C),IA(M08C),IA(M09C),IA(M10C),IA(M11C),IA(M12C),
                *IA(M13C),IA(M14C)
002502    97     CONTINUE
002505           PRINT 105
002510    105    FORMAT(*R*)
002510           GO TO 4
002511    111    FORMAT(1X,3(I5,5X,A1,R1,A1,R1,A1,R1,A1,R1,A1,R1,1X,3A1,1X,A1,10X))
002511    112    FORMAT(1X,3(10X,  R1,A1,R1,A1,R1,A1,R1,A1,R1,A1,R1,1X,3R1,1X,A1,10X))
002511    113    FORMAT(1X,3(10X,  A1,R1,A1,R1,A1,R1,A1,R1,A1,R1,A1,1X,3A1,1X,A1,10X))
002511    114    FORMAT(1X,3(I5,5X,R1,A1,R1,A1,R1,A1,R1,A1,R1,A1,1X,3R1,1X,A1,10X))
002511           END
036400
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