D R A F T

CARTOGRAPHIC AND DIGITAL STANDARD FOR GEOLOGIC MAP INFORMATION

Principles, content, symbols, colors, patterns, and codes

Prepared on behalf of

The Federal Geographic Data Committee, Geological Data Subcommittee

by the

U.S. Geological Survey

with cooperation from the Association of American State Geologists

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Foreword

The "Cartographic and Digital Standard for Geologic Map Information" provides guidance to the earth science community for the representation of geologic information on maps. The purpose of this document is to standardize geologic information on maps prepared in both electronic (digital) and traditional (printed) formats. Collection of geologic information incorporates a significant amount of subjective observation and interpretation that cannot be standardized. However, representation of geologic data and interpretations on maps must be standardized for several reasons. The application of geologic map information to other disciplines such as engineering, environmental protection, or public health is expanding rapidly; information must be represented consistently for engineers and scientists in those other disciplines to enable them to understand and apply uniformly geologic data gathered from a variety of sources. For applications such as civil engineering, the locations of contacts, boundaries, faults, and point data must be represented consistently and uniformly; use of the geologic map standard, both at the time the data are collected and subsequently when they are represented on electronic or traditional maps, will ensure proper understanding and consistent interpretation of the data.

Second, many geologic data are now being prepared electronically for rapid application and analysis. Often the earth scientist does not assemble the electronic map data for analysis. Specialists in computer cartography assemble the electronic data; they cannot improve either the quality or the character of the original data. The quality of the final map depends on the application of a standard by all participants in the map-making process. Application of the standard begins with the earth scientist who records and transfers the field and (or) remotely sensed data to publishable format. Clear and effective communication of the geologic map data

among the earth scientist, the digital cartographer, and the subsequent user begins with the use of standard data representation.

Development of the geologic map standard contained in this report began in the U.S. Geological Survey in 1989. The U.S. Geological Survey enlisted cooperation from the Association of American State Geologists, which provided a representative to the working group. The working group included representatives from a spectrum of geological disciplines that make general- and special-purpose geologic maps. In 1994, the project was incorporated in activities of the Federal Geographic Data Committee, Geological Data Subcommittee, in order to expand the review and application of the draft standards by Federal agencies that use and (or) gather geologic map information.

The draft of "Cartographic and Digital Standard for Geologic Map Information" is intended for public review, application, and comment for 2 years. At the end of that time, comments will be analyzed carefully and the draft standard revised for release as a Federal standard.

Members of the working group that developed the draft standard include:

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1. GEOLOGIC MAP INFORMATION

1.0 INTRODUCTION

Scientific requirements are set by the discipline of the earth sciences. Formats for representing geologic map information have developed through nearly a century-and-a-half as a response to expanding scientific sophistication and requirements to record complex geologic information accurately. Standardization of those formats has progressed irregularly as the focus and application of geologic studies have changed through time. However, the need for standards for earth-science maps has acquired a new sense of urgency because of the requirements of digital systems. Explicit standards required by computer graphics programs cannot be allowed to change scientific requirements set by the discipline. Rather, the expanded capabilities in preparation, data manipulation, and publication of earth science maps must be exploited to assist scientific endeavors. Digital standards must accommodate the capabilities of the hardware and software systems to be used, but they must start with the science.

Graphic practices for printed color and black-and-white general-purpose geologic maps have been established and thousands of maps published. The definitions and organization provided here set a standard for practice in preparing geologic maps from the field to publication. This standard includes one format for digital representation of map information. As requirements change regarding the type and representation of geologic data gathered, departures from this standard may be needed. With adequate and precise description, such departures will be encouraged to meet the needs of geological sciences.

Geologists generally use maps and aerial photographs in the field at scales near 1:24,000, even if the final mapping is destined for release at a smaller scale. Direct geologic mapping on sheets at scales of 1:100,000 or smaller is rarely desirable because base maps at larger scales present more detail usable for location and interpretation and provide space to plot geologic detail required in working out geologic problems. Geologic maps at scales of 1:100,000 and smaller are almost always compiled by generalizing larger scale maps. Data for small-scale maps are generally drawn from maps compiled by many individuals. The compiler is less directly familiar with the whole and must rely more on interpretation of the maps drawn by others.

This document sets forth a standard for developing general-purpose geologic maps at scales of 1:24,000 and 1:100,000, with easy extension to maps at other scales, and provides definition and discussion, some directed to make nearly 800 common understandings explicit, to assist digital representation. The restriction to 1:24,000 and 1:100,000 scales and to general-purpose geologic maps has been adopted to reduce the number of elements to a manageable group, as well as to avoid expanding discussion to the special needs of very large scale maps, such as mine maps, small-scale compilation maps, and special-purpose maps.

Any map provides a particular picture of the reality it represents. The general geologic map provides a view of the geology of an area that provides the distribution of mappable rock units, the structure of the area, and through interpretation, the geologic history of the area. It does not specialize on the details of a single element. To provide this general view, it avoids details that would obscure the broader picture. A compromise always exists between showing the details of the distribution of small patches of surficial units and the distribution of bedrock units. As such, the general geologic map is much more than an engineering representation. Problems are

different in different geologic terranes and in different physiographic provinces. Experience over the past years helps to define the most useful content for a general geologic map, if we bear in mind that the interests and capabilities of the author and the character of a particular area will inevitably bias the content of the map. Special-purpose maps, or derivative maps, in part based on the general geologic map, can be drawn to provide more details of a particular view of the geology of the area and to complement the more general view.

This cartographic and digital standard for geologic map information presents the standard in three major parts: (1) the standard for geologic map information, including content and representation of map information; (2) the standard for graphical and digital representation of map symbols, including one format of digital coding for geologic features; and (3) the standard for the design and representation of colors and patterns on geologic maps.

1.0.1 CARTOGRAPHIC STANDARD AND ACCURACY OF LOCATION OF GEOLOGIC SYMBOLS

The application of a standard for geologic map information begins at the time data are recorded during field investigations or primary interpretation of remotely sensed data. Scientific identification, characterization, and representation of relations among geologic elements with positional accuracy are not improved by subsequent traditional or electronic (digital) map preparation. Identification and characterization of geologic elements and their relations have subjective components dependent on the background and interests of the scientist investigating those elements or on the purpose of the investigation. However, recording scientific observations, measurements, and, to some extent, the subjectivity of the observations on a map must be done in standard format and content in order to facilitate communication among the scientist and users of the map information.

The importance of a standard for the accuracy of geologic mapping was formalized in 1956 in the U.S. Geological Survey (W. H. Bradley, 1956, written communication). That standard was gradually recognized, but not rigorous followed, by other mapping organizations through the years. The standard was defined in terms of the accuracy of location of geologic lines and points:

> Solid lines should be used to indicate accurate locations of features that are geologically identifiable within the plotable limits of the [base] map and that can be located from exposures or other evidence within 1/25 inch [1 mm] on the map. Solid lines should generally be within 1/25 inch [1.00 mm] true position and in no case should they be mislocated with respect to geographically identifiable points more the 1/10 inch [2.5 mm]

on any map. Features that are only approximately located should be shown by long dashed lines; those that are indefinite or inferred, by short dashed lines; and those that are concealed, by dotted lines. The use of many dashed contacts or faults on a map is not to be construed as a detraction from the quality of the map, and for many maps, it may be undesirable or impossible to achieve sufficient accurate locations to permit use of solid lines.[1]

The quality of the map is not impaired, but rather enhanced because the reader is provided an indication of the accuracy of location.

In recent years the U.S. Geological Survey, followed by other organizations, substituted a solid line contact for the dashed contact (contact approximately located) on many maps. With this change, the geologist did not distinguish between different kinds of contacts according to accuracy of location. Although the legibility of some maps was increased (dashed lines of contorted traces may not be as legible as solid lines), in the main, dashed line contacts were not used in order to reduce costs of preparation of materials for publication. On many of the maps, dashed lines were used to indicate faults, located approximately. Dotted lines have consistently been used to indicate concealed contacts and faults.

Although no record exists of studies conducted to determine the accuracy of location of solid line contacts or other well-located features, discussions with geologists having extensive field experience indicate general belief that the standards suggested as originally defined are reasonable and proper guides to field practice. Accordingly that original standard is formally

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[1]Metric conversions added here. Throughout the remainder of the *Cartographic and Digital Standard for Geologic Map Information,* metric units will be used following the Federal standard for metrification. Previously, technical standards for map accuracy and cartographic specifications were given in thousandths of an inch (U.S. customary units). Table 1.0.2.1 provides conversion values from metric to U.S. customary units. In some cases, metric conversion values have been rounded to the nearest 0.005 mm, although in practice that measurement cannot be met precisely by traditional or electronic map preparation techniques.

adopted here. A continuous line is used if the location of the intersection of a geologic surface and the Earth's surface is located within 1.00 mm at the scale of the base map. The dashed line and other symbology for approximate locations, concealed boundaries, and inferred boundaries are adopted in this standard (Section 2.0).

1.0.1.1. *The 1.00 mm accuracy standard refers to locations of lines and points with respect to local geographic features portrayed on the base map.* In areas of gently dipping geologic surfaces, locations of contacts are generally determined with respect to elevation and plotted according to the topographic contours. Location of the majority of contacts within one contour interval is generally regarded as feasible. Steeply dipping geologic surfaces are located differently, and the 1.00 mm accuracy standard is more readily applicable. The accuracy standard also applies to locations of symbols for geologic features.

1.0.1.2 Symbols representing an observation applicable to a "local" area, as well as to a point of observation, can be moved for the sake of cartographic clarity but should not be moved more than 2.5 mm from the point of observation and should never be plotted in a unit different from that in which observations were measured.

1.01.3. The angles of strike and dip of surfaces and the bearing and plunge of linear elements should be measured and plotted to the nearest degree. If a different accuracy convention is used, such as reporting to the nearest 5 degrees, this convention should be described in the explanation of map symbols. Appropriate symbology for contorted beds or approximate data can be drawn

from the list of symbols in this report (Section 2.0) and used to convey a sense of reality for the observations recorded.

1.0.1.4 For reconnaissance or preliminary geologic maps reporting original mapping, dashed and dotted line symbology is used, but note that the 1.00 mm accuracy standard may not be met for the majority of the "solid" lines. The title of the map adequately explains the difference in accuracy to be expected (Section 1.3), and the map reliability diagram summarizes the mapping methodology and the density of observations to provide a user with a general view of the positional reliability of the data (Section 1.6).

1.0.1.5 Standards also make explicit a set of requirements related to science. Topographic base maps are now available at a scale of 1:24,000, and soon at 1:100,000, for all of the conterminous United States, Hawaii and most U.S. possessions, and at 1:63,360 for Alaska. The standard for geologic map information now requires that a geologic map must be on a topographic base drawn to Federal map standards. Such a base is required so that interpretation of the intersection of a geologic surface with the ground surface, such as a contact or fault surface, can go beyond the position of a line on a flat map to an interpretation of the configuration of this surface in three dimensions. Electronic representation of the geologic elements on a digital topographic base map can facilitate calculation of volumes, surface areas, depths to surfaces, and a variety of derivative information for scientific, engineering and other societal applications.

1.0.1.6 Where both precision of location and geologic control, that is, spacing of outcrops, fall within the 1.00 mm accuracy tolerance, lines or points shown on a map are considered accurate. Each one of the data points shown on a map is expected to fall within the tolerance standards for accuracy, except as otherwise noted in the specifications of this standard. Those falling beyond this tolerance are either approximate or indefinite. Approximate contacts do not carry a stated or implied accuracy, except as determined by the location of exposures or observation points that may be denoted by symbols, such as the limits of outcrops.

1.0.2 CONVENTIONS USED IN THIS STANDARD

For application and review discussion, discrete elements of the standard are assigned reference numbers. Major parts are numbered in sequence: 1.0 Geological map information; 2.0 Geologic map features: symbols, graphical standards, and attribute codes; and 3.0 Colors and patterns. Following a decimal point, sections, topics, or classes within the major parts are each assigned a number. Within a section, topic or class, individual standards or symbols follow in order, each separated by a decimal from the numbers of the higher organizational elements. Tables and illustration numbers are keyed to the appropriate section or topic of the standard using the same decimal system.

1.0.2.1 Measurements for the standard are in metric units. Previous descriptions of map accuracy and symbols have been in U.S. customary units. Table 1.0.2.1 provides conversion values from customary units to metric units used in this standard. In 1995, available

Table 1.0.2.1. Metric-to-U.S. customary unit conversions used in "Cartographic and Digital Standard for Geologic Map Information"

Measurement in millimeters *(Rounded for use as conversion standard)*	**Measurement in inches**	**Measurement in millimeters** *(Rounded for use as conversion standard)*	**Measurement in inches**
25.40	1.000	0.875	0.035
0.025	0.001	1.00	0.040
0.125	0.005	1.25	0.050
0.15	0.006	1.50	0.060
0.175	0.007	2.00	0.080
0.20	0.008	2.50	0.100
0.25	0.010	3.00	0.120
0.30	0.012	3.125	0.125
0.35	0.014	3.50	0.140
0.375	0.015	4.50	0.180
0.45	0.018	5.00	0.200
0.50	0.020	10.00	0.400

U.S. topographic base maps (1:24,000 scale and some 1:100,000 scale) use U.S. customary units and have a scale to convert linear measurements to metric units. Many 1:100,000 topographic maps used as bases for geologic data are in metric units; each map has a scale for conversion to U.S. customary units. Geologic maps printed on a base map in customary units should show geologic cross sections in units of the base map, with the conversion value provided at the base

of the cross sections. Map text values and stratigraphic columnar sections are in metric units. In cases where the base map is in metric units, all geologic map and geologic map reference information must be in metric units.

1.0.2.2 This standard refers throughout to typefaces and sizes for descriptions of symbols and map information. Two categories of typefaces are used on geologic maps to enhance clarity, readability, and distinctions among kinds of data: (1) Typefaces in which the upright lines of letters are ornamented with short lines (serifs), and (2) typefaces in which the upright lines of letters are straight (sans serif, sometimes shortened to sans). This standard refers to two principal typefaces Souvenir (serif) and Univers (sans serif). These typefaces are available for map making in tradition and electronic formats. Similar typefaces may be substituted. For example, Times Roman or New Times Roman typefaces produce characters similar to the Souvenir typeface. Helvetica and Arial typefaces have sans serif characters similar to Univers. Table 1.0.2.2 provides the abbreviations of typefaces and sizes used in this standard. Customarily, type sizes are given in points, rather than metric units. This standard continues the use of points; however, Table 1.0.2.2 also provides conversion values from points to millimeters.

Table 1.0.2.2. Abbreviations for typefaces and conversion of type points to metric units

ABBREVIATIONS FOR TYPEFACES[1]			
Abbreviation	Typeface	Abbreviation	Typeface
U	Univers	SL	Souvenir light
UL	Univers light	SLI	Souvenir light italic
UCI	Univers condensed italic	SM	Souvenir medium
ULI	Univers light italic	SMI	Souvenir medium italic
ULC	Univers light condensed	SB	Souvenir bold
UE	Univers expanded		
UB	Univers bold		
UBI	Univers bold italic	TG	Trade Gothic

CONVERSION: TYPE POINTS TO MILLIMETERS	
Points	Millimeters
6	2.08
7	2.43
8	2.78
9	3.13
10	3.47
11	3.82
12	4.17
18	6.25
24	8.33

[1] In some digital fonts and type production equipment, Souvenir bold is equivalent to Souvenir medium of this table. Regardless of the program weight designation, the appearance of Souvenir medium type is preferred as the heavier Souvenir typeface.

1.1 GEOLOGIC MAP CONTENT STANDARD

The standard for content of a geologic map applies to all information necessary to depict the geologic data for an area. Three categories of information are covered by the standard: (1) Map reference information, required to identify the geologic map and to define its area, scale, lineage, and base map for the geologic data; (2) the geologic map data themselves, including the geologic map, geologic cross sections, and, if appropriate for an area, a stratigraphic columnar section; and (3) geologic reference information for the map data. Although the geologic map data are the focus of the publication, they cannot stand alone. Together the three categories of information define the full map content for both electronic and conventional publication formats. Figure 1.1 illustrates each element of a geologic map and provides an example of a graphical layout for a geologic map and supporting information. Table 1.1 lists each element within the three principal categories of information. Content elements required by the standard for every geologic map are shown in boldface on Table 1.1. Each element is keyed by reference number to Figure 1.1, and notes on usage define the character and application of each element.

1.1.1 Map reference information

Map reference information includes the metadata that describe the geologic map, its source, and its base map(s). For the geologic map itself, the reference information includes all information necessary to identify, locate geographically, and catalog the geologic map. Data required to identify the geologic map include: The name of the map, the county and State of the map area, the author(s), compiler(s), or digitizer(s) name; the year of publication, the publishing

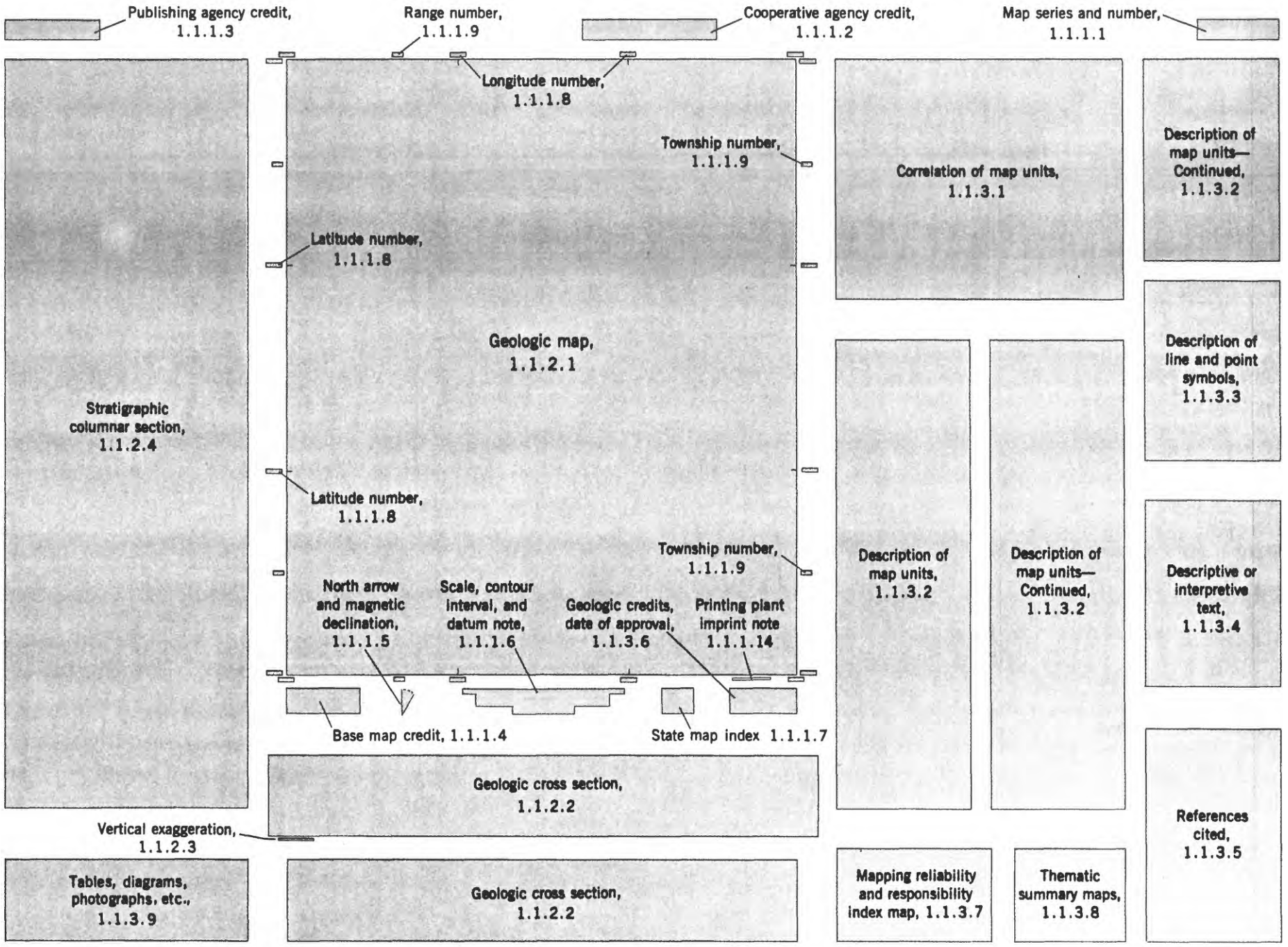

Figure 1.1. Geologic map content

Table 1.1. Geologic map content: summary of standard elements of a geologic map by principal category of map information

Geologic map content standards are keyed to Figure 1.1 by reference numbers for map elements. **Boldface** reference numbers and map elements refer to standard elements that must appear on all geologic maps. Note that the final layout of a geologic map may vary from that shown in Figure 1.1, depending on factors such as the shape of the map area, the number of geologic cross sections provided (Section 1.1.2), the amount of information to be included the geologic reference information (Section 1.1.3), and the size capacity of the printing or plotting equipment.

1.1.1 Map Reference Information

Reference number	Map element	Notes on usage	Recommended typeface	
1.1.1.1	**Map series and number credit**	Assigned by the organization or agency publishing the map Includes reference to pamphlet accompanying the map, if applicable	Series Number Pamphlet note	S-12 S-13 SI-10
1.1.1.2	**Cooperating agency credit**	Provides credit to agency or agencies participating in funding and(or) mapping when different than publishing organization	Prepared in cooperation with Agency	S-9 S-11
1.1.1.3	**Publishing organization or agency credit**	Provides credit to publishing organization or agency	Agency	S-12
1.1.1.4	**Base map credit**	See text, section 1.5	Text	U-8
1.1.1.5	**North arrow and magnetic declination**	Approximate mean declination cited under arrow	Text	U-5
1.1.1.6	**Scale, contour interval, and datum note**	Map scale as numerical ratio Bar scales in U.S. conventional and metric scales of the base map Contour interval in units of the base map Vertical datum with year Variation in magnetic declination across sheet, scales 1:100,000 (Alaska) and smaller	Ratio Bar scale units Contour interval Datum Declination	U-8 U-7 U-8 U-7 U-7
1.1.1.7	**State map index**	Outline of State with State name in center, showing area of geologic map in black	Type	U-6

Reference number	Map element	Notes on usage	Recommended typeface	
1.1.1.8	**Latitude and longitude numbers and reference marks**	Latitude and longitude outside map border, all sides of map; must be present on all geologic maps and illustrations	Type	U-8
1.1.1.9	**Township and range numbers** or other land survey reference numbers or marks	Township and range numbers outside map border, all sides of map; must be shown for all surveyed land areas	Type	U-7
1.1.1.10	**Title of geologic map**	See text, section 1.3	Type	SB-24
1.1.1.11	**Author, compiler, or digitizer credit**	See text, section 1.4	Type	SB-18
1.1.1.12	**Date (printing year)**	Year of publication	Type	SB-12
1.1.1.13	Map distribution and sales note	Optional for organization or agency publishing the map	Type	U-7
1.1.1.14	Printing plant imprint note, if applicable	Optional for organization or agency publishing the map; shows locality of printing plant and printing job number	Type	U-5

1.1.2 Geologic Map Data

1.1.2.1	**Geologic map**	Line, point, and area geological data; labels. Geologic data on topographic base map; data fit the topography	Labels See symbols standard	S-8
1.1.2.2	**Geologic cross section(s)**	Geologic cross section; vertical scale equals horizontal scale of map, except for areas of extensive thick surficial deposits which can be shown on a geologic section with vertical exaggeration Units of measurement are those of base map. Insert metric conversion scale at base of geologic section	Names of map features Names of geologic features Vertical scales Unit labels	U-8 U-6 U-6 U-8
1.1.2.3	**Vertical exaggeration note**	Amount of vertical exaggeration, if any, used in constructing the geologic cross section	Vertical exaggeration	U-5

1.1.2.4	Stratigraphic columnar section	Strongly recommended for all maps; show right margin of column with relief representative of relief of rocks on outcrop; use lithologic symbols (section 3.1, p. C38, C39) and fossil symbols (2.26.3) as appropriate	Lettering U-8, U-10

1.1.3 Geologic Reference Information

Reference number	Map element	Notes on usage	Recommended typeface
1.1.3.1	**Correlation of map units**	Boxes are arranged according to field stratigraphic relations among geologic units; size of box represents stratigraphic relation with adjacent units, not rank or thickness; boxes touch vertically where units are conformable; boxes are separated along unconformities; boxes may be arranged by geographic area or structural plate where stratigraphic differences warrant Braces on right delimit series or epoch, system, or period	Unit labels U-8 Unconformities S-8 Series/system epoch/period S-8
1.1.3.2	**Description of map units**	Summary description of map units, including rock type, color, distinctive characteristics, and thickness (m). Units are described in order of increasing age from top to bottom and left to right. Name of stratigraphic unit precedes the description Box on left edge of unit description gives unit label and color	Heading SB-10 Unit name SB-9 Description S-9 Labels U-8
1.1.3.3	**Description of line and point symbols**	Line and point symbols are those that appear on the map. Free form symbols and departures from standard must be defined	Symbol name SB-9 Symbol description and qualification S-9 Symbol numbers and letters as in standard (Section 2.0)

Reference number	Map element	Notes on usage	Recommended typeface
1.1.3.4	Descriptive or interpretive text such as geologic summary, structural geology, tectonics, environmental or economic geology	Text can describe geologic relations among units, tectonics, age determinations, results of topical studies	Heading SB-10 Subheading S-9 Text S-9
1.1.3.5	**References cited**	Cites references for all published work cited in the descriptive text, figures, and index maps such as reliability and compilation sources Format of citation follows standard (text section 1.8)	Heading SB-10 Text S-9
1.1.3.6	**Geologic mapping credit with date of mapping; assistantship and editor credit; date of approval**		Text U-8
1.1.3.7	**Mapping reliability and responsibility index map; showing sources of data compiled in map compilation, if appropriate**	Map showing latitude and longitude displays areas of detailed, generalized, and reconnaissance mapping with explanation; combined with areas mapped by different contributors, or areas of maps by others used in compilation; formal references to published mapping used in compilation are cited in 1.1.3.5. See text section 1.6 for discussion	Labels U-7, U-8 Latitude and longitude U-7 Font and size can be adjusted for clarity and for inclusion of selected geographic information
1.1.3.8	Thematic summary maps, such as tectonic map, facies map, sample locality map	Can be included as space permits; each map must be labeled with latitude and longitude; symbols follow standard	Typefaces and values follow those of 1.1.3.7
1.1.3.9	Tables, diagrams, and photographs	Tabular information such as chemical analyses, radiometric age determinations, and photographs as space permits	Headings S-9 Text S-8

organization, and map series and number. Data necessary on every map to define its location include the latitude and longitude, reference systems shown, such as State plane coordinates, land grid, or other land-reference systems, scale, magnetic declination and contour interval with reference datum.

For the base map on which the geologic data are presented, the reference information identifies the source agency or organization, map name(s), edition(s), projection, scale, reference coordinates, and datum. Regardless of the publication format, each of these elements must accompany the geologic map in order to meet the standard (Table 1.1 and text section 1.5).

1.1.2 Geologic Map Data

The geologic map including all line, point, and area geologic data with labels, all displayed on a topographic base map or rectified base image(s), is the focus of the standard. These geologic data must meet the standard for positional accuracy and symbology provided herein. Geologic data must fit the topography as represented on the base topographic map or on images, such as an orthophoto quadrangle, used to represent the Earth's surface in the mapped area. A geologic map presented on a simple planimetric base map does not meet the standard.

One or more geologic cross sections, which illustrate the author's interpretation of the geology from the Earth's surface downward in a section normal to the plane of the geologic map, are an essential element (1.1.2.2) of the geologic data. Along the line of the topographic profile for the section, the geology must coincide precisely with the geology shown on the map. At depth, the geologic interpretation must be consistent with geologic relations projected into the section from adjacent areas or with data from bore holes and geophysical surveys in the area. The standard for positional accuracy cannot be maintained at depth in the section; however, symbology standards do apply. For most areas, the vertical scale of a geologic cross section should equal the horizontal scale. The vertical scale displayed at the end of each section is in

the same units as the geologic map. A conversion scale to the alternate unit of measurement, whether metric or U.S. conventional, is displayed at the base of the section. Generally, only in areas where geologic units at the surface are very thin but extensive, or stratigraphic relations among them are complex, are geologic cross sections drawn with vertical exaggeration. In such cases the amount of vertical exaggeration must be provided in a note at the base of the geologic section (element 1.1.2.3).

The usefulness of a geologic map, particularly in areas underlain primarily by sedimentary deposits, is greatly enhanced by the inclusion of a stratigraphic columnar section that describes the sequence of units. A stratigraphic columnar section provides a map user with a graphic image of the rock types from the base to the top of the succession. The columnar section may convey other information such as the weathering relief of the units, their fossil content, and the stratigraphic position of aquifers, units that might contribute to geologic hazards, and accumulations of minerals or fossil fuels that might have economic significance. A stratigraphic columnar section may be appropriate for areas of extrusive and shallow intrusive volcanic rocks. For map areas across which sedimentary, metamorphic, volcanic, or igneous intrusive facies change significantly or are complex, a facies diagram (element 1.1.3.8) may illustrate units more effectively than a columnar section. This standard provides graphic standards for rock types (Section 3.2, p. C-38, C-39) and fossil types (Section 2.26, p. 2.1-51) for columnar sections and facies diagrams on maps. The potential amount of space on a map sheet should not be the controlling factor for the inclusion of a columnar section. Rather, the guiding principle for all maps is that relations among units or facies of all rocks and deposits shown on the map must be

explained clearly. Either a columnar section (element 1.1.2.4) or a facies diagram (element 1.1.3.8) is a graphic supplement that clarifies information required in different format in the correlation and description of map units (elements 1.1.3.1 and 1.1.3.2). The agency or organization that funds the geologic mapping and the map author must determine together what form of presentation is most effective for the broadest audience of map users.

1.1.3 Geologic Reference Information

Geologic reference information includes all information necessary to (1) explain geologic units and relations shown on the map; (2) explain all line and point symbols and colors and patterns used; (3) reference information derived from published and unpublished sources; (4) identify the general reliability of the map data; (5) provide credit to persons who performed the mapping or compilation of the map data, or who had major roles in producing the map; and (6) provide descriptive information that will assist the map user in interpreting the map data in the context of its regional setting, tectonic relations, geologic history, and environmental or economic significance.

Section 1.1.3 of Table 1 defines the elements for geologic reference required or recommended by this standard. Notes on usage are essential: they summarize the content or graphic representation required for each element. Separate text sections provide extended descriptions for elements 1.1.3.3 (Part 2, Section 2.1–2.58), 1.1.3.5 (Part 1, Section 1.8), 1.1.3.7 (Part 1, Section 1.6), and 1.1.3.8 (Part 1, section 1.7).

1.2 NATIONAL STANDARDS: SPATIAL DATA TRANSFER STANDARD AND CONTENT STANDARDS FOR DIGITAL GEOSPATIAL METADATA

The cartographic and digital standard for geologic map information must be used within the framework of existing Federal information processing standards, including the Spatial Data Transfer Standard and the Content Standards for Digital Geospatial Metadata. These standards pertain specifically to all primary digital spatial data assembled for a geologic map. However, a digital map derived by conversion of a map originally prepared by tradition methods must also conform to the national standards. As long as some geologic maps are produced by using traditional methods, appropriate information must be contained on them to allow subsequent full conversion to digital format in conformance to the standards. The purpose of this section (1.2) is not to detail the content and application of these standards, but to call the attention of the geologist and geologic cartographer to these standards applicable to digital geologic map information and production.

In 1992, the National Institute of Standards and Technology issued Federal Information Processing Standards Publication 173 (FIPS 173), which defines the Spatial Data Transfer Standard (STDS). The standard "provides specifications for the organization and structure of digital spatial data transfer, definition of spatial features and attributes, and data transfer encoding."[1] Those specifications facilitate the transfer of digital spatial data among different

[1] National Institute of Standards and Technology, 1992, Spatial Data Transfer Standard (SDTS): Federal Information Processing Standards Publication 173, p. 1.

computer systems. In succession, the SDTS (1) defines the conceptual model for spatial data, (2) defines standard two-dimensional objects to support major types of data operations; (3) defines a standard for reporting data quality; and (4) defines specifications for data transfer. The standard is set forth in detail in FIPS 173, and conformance to this national standard is required for digital geologic map information. At the time of preparation of the geologic map information standard, methodology and software for routine application of the SDTS are under development. Further information may be obtained from the Executive Secretary, Federal Geographic Data Committee, U.S. Geological Survey, 590 National Center, Reston, Virginia 22092.

Information about the content, quality, condition, and other characteristics of data comprise metadata. Published paper geologic maps that meet the required geologic map content standards 1.1.1.1 through 1.1.1.12 and 1.1.3.6 and 1.1.3.7, above, display metadata for that map in a format that is helpful to a potential user who has access to the map sheet. Although some of that information is available in published bibliographies of geologic information, significant information such as the map lineage (history of the mapping, subsequent modifications to the map, and sources of the map data), the quality of the data, including positional accuracy of both the geologic information and the base map(s) and accessibility of the data, are generally not included in a bibliographic citation. Electronic production and access to map information require a different format for the map metadata.

U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

DRAFT CARTOGRAPHIC AND DIGITAL STANDARD FOR GEOLOGIC MAP INFORMATION

by

U.S. Geological Survey

Open-File Report 95-525

Prepared in cooperation with the Federal Geographic Data Committee, Geological Data Subcommittee, and the Association of American State Geologists

1995

TO CUSTOMERS INTERESTED IN PURCHASING OFR 95-525 or 95-526:

The U.S. Geological Survey (USGS) Open-file Report (OFR) 95-525 ("Cartographic and digital standard for geologic map information") and the accompanying diskettes (OFR 95-526) have been reviewed by the USGS, the State Geological Surveys, and the Geologic Data Subcommittee of the Federal Geographic Data Committee. The review, published as USGS OFR 96-725, describes flaws in those reports and explains the plan for preparing a revised set of cartographic standards for geologic maps.

Before you purchase either 95-525 or 95-526, you may want to read the review document; if you like, we will send it to you (free of charge, except for postage) or you may read it on a USGS Web site (see URL: *"http://ncgmp.usgs.gov/ngmdbproject/standards/carto/OFR95-525review.html"*). For more information about the standards development activities underway at the USGS, see the Web site *"http://ncgmp.usgs.gov/ngmdbproject/home.html"*.

If you decide to purchase OFR 95-525, the cost of reproduction is as follows: 1) text b&w with color reproduction of pages showing map symbols, colors, and patterns -- $159.75; 2) text b&w with color reproduction of pages showing map symbols (pages showing colors and patterns would be b&w) -- $96.75; or 3) all pages b&w -- $37.50.

All geologic maps developed in digital format must now include information that meets national Content Standards for Digital Geospatial Metadata.[2] The standard defines the information necessary for a potential user of the digital map to determine (1) that the data exist, (2) the fitness of the data for application, (3) the means and conditions for accessing the data; and (4) the information needed to transfer and use the data. The metadata content standard specifies and provides the formats to be used for provide digital map information.

The "Cartographic and Digital Standard for Geologic Map Information" requires that digital geologic map information conform to both the Spatial Data Transfer Standard and the Content Standards for Digital Geospatial Metadata.

[2] Federal Geographic Data Committee, 1994, Content Standards for Digital Geospatial Metadata, 54 p. with 3 appendixes. Available from the Executive Secretary, Federal Geographic Data Committee, U.S. Geological Survey, 590 National Center, Reston, Virginia 22092. Internet address: gdc@usgs.gov Anonymous ftp: fgdc.er.usgs.gov

1.3 MAP TITLE

The title of a geologic map must succinctly reflect three principal aspects of the map: (1) the character of information presented on the map, (2) the geographic area covered, and (3) the accuracy of location of geologic features and relative distribution or amount of original data shown on the map. The title provides a means for the map author or compiler to define the area and extent of data, and for a potential user to gain a sense about the extent of original information presented on the map from its bibliographic citation.

1.3.1 Character of information presented on the map

The map title tells a potential user briefly, but accurately, what kind of data the map shows. If the geologic map displays the general geology of an area, including bedrock and surficial geologic units and structure, the title includes the words "Geologic map of...(area)." A map emphasizing the distribution of specific units, such as those of Quaternary age or surficial materials, would state the specific subject of the map, such as "Quaternary map of ...(area)," or "Surficial materials map of ...(area)," respectively. A map displaying only bedrock geologic units is a "Bedrock geologic map of ...(area)." Other examples of titles denoting limited map content are "Structure contour map of...(area)," "Mineral resource potential map...," "Landslide map.." or "Volcanic hazard map... ."

Regardless of the map scale, the title "Geologic map..." should be applied exclusively to a geologic map which shows surficial materials and bedrock units and structure, that is, to a

general- purpose or multipurpose geologic map. The accuracy of the map meets the base map accuracy standard, with line continuities reflecting positional departures from the accuracy standard.

1.3.2 Geographic area covered by the map

The geographic area of a map is defined by a quadrangle name, the name of a county or larger administrative unit, the name of a land management unit, or the name of a physiographic area such as a mountain range, a basin, or province which the map covers. The map title must always include the State or States in which the map area is located. Typically only geologic maps of 7.5-minute quadrangles and counties include the name(s) of the county, or counties, in the map title. Examples include, "Surficial geologic map of the Nashua North quadrangle, Hillsborough and Rockingham Counties, New Hampshire," "Geologic map of the Bairoil quadrangle, Carbon, Sweetwater, and Fremont Counties, Wyoming," or "Surficial materials map of Allen County, Indiana," In these cases the title includes the name and county of the quadrangle from the quadrangle topographic base map or from the index to topographic mapping for that State.

Titles of maps of quadrangles other than those of 7.5-minute (1:24,000) scale, include both the quadrangle name and the size of the quadrangle in minutes or degrees latitude and longitude. Examples include "Bedrock geologic map of the South Boston 30' x 60' quadrangle,

Virginia and North Carolina," or "Geologic map of the Kalispell 1° x 2° quadrangle, Montana and Idaho."

1.3.3 Accuracy and distribution or amount of original data

A map title conveys the distribution of original data presented on the map by modifier that incorporates both the method of assembling and the extent of the original data.

The title "Geologic map..." conveys to the potential user that the map contains original field observations or compilation of original geologic maps whose data were collected at a density appropriate to the scale of the original map, and whose accuracy is shown by appropriate line continuities and point locations. Thus, the density of original observations and data changes with smaller-scale maps. For a 7.5-minute quadrangle, for example, traverses at intervals of one-third to one kilometer, or detailed tracing of boundaries or faults across the quadrangle would provide data for a "Geologic map ..." of the quadrangle. By contrast, a traverse every 2-3 km yields discontinuous information for the quadrangle, so that the map should be referred to as a reconnaissance geologic map. However, data gathered at 1-3 km spacing on a 1:100,000-scale (30' x 60') map could provide sufficient detail to refer to the map as a "Geologic map of ..." without a modifier.

An earth science map made using a method other than geologic mapping contains the name of the method in its title. For example, a map developed entirely from geologic interpretation of aerial photographs is entitled "Photogeologic map of...(area)," or geophysical maps are given titles that reflect the geophysical technique used such as "Aeromagnetic anomaly map of...," or "Bouguer anomaly map of..." Maps derived by analytical techniques from such maps should be treated and named as derivative maps (see below).

The modifier "Reconnaissance," as in "Reconnaissance geologic map of..." identifies that the author used limited data, perhaps based on widely spaced traverses or other limited information together with extrapolation to produce the geologic map. The accuracy of feature location is not as high as on other types of geologic maps. In this case, the index diagram for map reliability (Section 1.6) documents the spacing of observations and the area for which limited or no observations exist but for which a reasonable interpretation of geologic relations can be made. Where limited data exist, an author should qualify the map title with reconnaissance rather than risk overstatement of the data content.

Maps that show generalized geologic relations, such as combinations of rock units into single units, simplification of contact or fault traces, or the exclusion of some existing data should be termed "Generalized..." geologic maps. The accuracy of location of some geologic boundaries and features may not be high. The author, in consultation with colleagues and the geologic map editor, should determine when a map is called a

generalized map. The explanation should incorporate a description of how the map information was generalized.

Earth science maps that utilize boundaries derived from previously published maps, and which incorporate data derived by analysis (mathematical or otherwise) of the information on the previous maps should be titled to reflect the derivative character of the map. The objective is to alert the potential map user that the map information is not original but that it was derived by analysis and configured to fit a previously published geologic map.

The same guidance for titles is applicable to maps that are prepared by compilation using either electronic or traditional techniques. The fact that the resulting map is a compilation and not original data is treated under map authorship (Section 1.4). A geologic map compiled from reconnaissance geologic maps retains an overall character as a reconnaissance map; it is titled such. In cases where reconnaissance data coarser than the compilation scale are combined with previously published geologic data appropriate to the map scale, the compilation should be termed a "generalized" geologic map. Alternatively, the differences in data abundance can be shown on the map with some hanging contacts and faults at the margins of the detailed information; the differences are explained in the index map to sources and reliability. Leaving abrupt terminations of detail among areas on a map intended for publication beyond an open-file series should be avoided.

Geologic maps released in open-file series can range from high quality to generalized to reconnaissance in character. Most organizations or agencies use open-file publication solely as a means to release data quickly. The title of each map released in an open-file series should bear a modifier, as in the sections above, that connotes the character, extent, and accuracy of the data shown on the map.

1.4 MAP AUTHORSHIP

Appropriate credit for authorship or compilership of maps is critical not only for the individual scientist(s) who made the map or for the individual(s) who assembled a map from different sources, but also for a user to distinguish original data from the same data that have been recast in a different format or medium. During an age in which earth science maps, previously made using traditional techniques to produce printed maps, are being reformatted in electronic (digital) format, proper credit is particularly important for each iteration of a map. When successive releases of data are made in electronic format, proper credit for the original map, as well as for successive iterations in different formats or media, must be part of the metadata (Section 1.2) that accompany each iteration.

As a result of widespread and increasing concern being raised in the electronic era about what constitutes authorship, compilership, or digitizing credit for an earth science map, the following new standard for authorship of geologic maps has been developed. The standard, together with language for credit on the map or in the electronic files, is summarized in Table 1.4. Explanations for the standard are provided below.

1.4.1 Author(s)

An author (or authors) of a map is the individual (or individuals) who made the original map from field observation and mapping or from remotely sensed data, or from a combination of geological and geophysical methods. Emphasis is on the fact that the individual(s) gathered

Table 1.4. Comparison of the cited map credit with the function of the individual(s) assembling the map and the character of the map product.

Reference number	Function of individual(s)	Map credit	Description of map product
1.4.1	author(s)	*Geology by*	Original geologic map made by the author(s) from observation and mapping in the field or from remotely sensed data or images. Original map was made at or nearly at the same scale as the published map.
1.4.2	compiler(s)	*Compiled by*	The map represents an assembly (compilation) of separate maps that were prepared from original field observation and mapping at the same or different scales by the compiler or by other earth scientists, or both. The compiler has exercised scientific judgement and skill in synthesizing and modifying information from the original maps to attain as uniform and consistent representation as possible across the area of the compiled map.
1.4.3	digital compiler(s)	*Digital compilation by*	The map is the product of digital compilation from one or more separate maps that were prepared originally in traditional (printed copy) or digital format by one or more authors or compilers. The digital compiler has exercised judgement in consolidating information from different files, file engineering, file structuring, and reformatting the data, and items such as color representation techniques, menus, tutorials, and descriptions of the data and software. The author(s) or compiler(s) of the original map(s) are usually different than the digital compiler.
1.4.4	digitizer	*Digital representation by*	A map, originally prepared and released in standard format, is prepared for separate release in digital format at the same scale and with the same supporting information as the original map. Files are structured, but no synthesis or modification of the original map information has been made.

the original map information. The original map data were collected at or nearly at the scale of the published map. The author has represented of the data according to the map accuracy standards in place at the time the data were collected. Credit on the published, or electronically released map (Element 1.1.1.11 of Geologic Map Content), is "Geologic map of the ...(area) By (the individual(s) name)." Original authorship is the only case in which the unqualified credit "By ... (name)" is assigned.

1.4.2 Compiler(s)

A "compiled" earth science map is a map that has been assembled from various original sources, printed or electronic or both. The compilation may itself be in traditional or electronic format. The compiler has assembled the original sources having the same or different scales and has exercised judgment in consolidating and representing the different original map data to achieve a uniform or evenly balanced map. The compiler may be the author of one or several of the original maps whose data have been transferred to the compilation. Even in cases where an individual has assembled most of her or his own published original mapping with some original mapping by other individuals in a compilation, the individual is credited as the compiler in map content element 1.1.1.11, through "Compiled by ... ." Heretofore, this principle has been ignored or abused, so that numerous examples exist of maps which are entirely compilations from existing geologic maps by primary authors but which have been attributed solely to the compiler as if the map author. Such an attribution is a disservice to the earth scientists who produced the original geologic map information incorporated in the compilation.

In summary, for any map in which several original geologic maps by different individuals, (possibly including the compiler as well) have been unified and consolidated into a single new map, the new map is attributed to the compiler by the exclusive phrase "Compiled by ...," accompanying the map title.

1.4.3 Digital Compiler

Existing earth science maps in demand are widely being digitized for release in electronic format. Generally the original data are unchanged, but line format and color may be adapted for processing by available electronic equipment. The original geologic data are recast in significantly different format. That recasting requires formatting the data, engineering and structuring the electronic files, and reformatting the color representation. Generally, operating menus and tutorials are added to the restructured data, together with the metadata defining the product. A digital compiler is responsible for these processes. The author of the original map is seldom the digital compiler.

Credit is accorded to the digital compiler in one of two ways, depending on the character of the digital compilation. (1) If the original map data are unchanged other than the restructuring in electronic format and addition of menus, tutorials, and metadata, the title of the product is:

Geologic map of the (area name) by (original author(s))
Digital compilation by (digital compiler)
Date

(2) If during digitization, the digital compiler uses other original geologic information to supplement the original map information which also is being digitized, the digital compiler is credited for the map as follows:

Geologic map of the (area name)
Digital compilation by (name of digital compiler)
Date

and the explanation for the map or the accompanying text states clearly that the geologic map is modified from the original map: (author(s)), (date), (map name and scale), and (publishing organization).

1.4.4 Digitizer

In other cases where original geologic maps and supporting information are digitized without change, other than file structuring, the individual who performed the digitization is credited by:

Geologic map of the (area name)
By (original author(s) name(s))
Digital representation by (digitizer's name)

In each case, care must be exercised to give proper credit to the individuals who first gathered and released the geologic map data through publication, as well as to the individuals who subsequently added value by compilation with other original data, by digital compilation, or by digitizing the original map information.

1.5 GEOLOGIC INFORMATION AND BASE-MAP SPECIFICATIONS

A map references position on the Earth's surface in two ways: (1) By geodetic coordinates such as latitude and longitude and (2) by relation to geographic features, including topography and cultural features. On geologic maps that have a topographic base, position is determined relative to geographic features. Geodetic coordinates are determined from the base map. Although geodetic coordinates can be determined with great accuracy by using satellites and global positioning systems (GPS), the techniques are not yet widely applied to geological mapping. The user of a geologic map is dependent on locations relative to the geographic features shown on the base map. If a base map is less than perfect, locations may differ if they were determined by using different techniques or if they were determined relative to different geographic features. For gently dipping contacts, elevation may be the most important aspect of location because of its importance to interpretations of structure. For a steeply dipping fault, a position relative to a notch in a ridge may be more important., An ideal map base would provide no disagreements due to discrepancies between the base map and geodetic position of a geologic element determined by GPS or other field survey method. *But in practice, regardless of the scale of the base map, the "geology" must be adjusted to the topographic base map.*

Map projection and scale are the two fundamental characteristics of all flat maps. A geometric projection is required so that a flat sheet can represent the surface of the solid Earth, a surface that curves in all directions. The choice of map projection is made to accommodate the needs of the map user, such as requirements for preserving angular relations, constancy of

linear scale, or shape of areas across the entire map. The larger the area, the more maps drawn to different projections differ from each other.

The scale of the map determines its size, what can be legibly plotted on it, and the accuracy of features relative to the ground. In this document we assume that a topographic base map exists, that this map is drawn to the Federal map accuracy standard[1], and that it can be changed by the geologist only by the addition of new, or modification of existing base, information such as highway rights-of-way, pipeline or transmission lines, dams, and shorelines of reservoirs. Positions of the new data must conform to Federal map accuracy standards. The new base map information is essential in order to aid a user of both the geologic map and the base map in location and interpretation of relations shown on the map.

In view of the importance of the base map to representation of the geologic data, complete reference to the base map must be cited on the geologic map (Figure 1.1, reference no. 1.1.1.4). On a printed or plotted geologic map, the base map reference must include the:

1.5.1 Organization or agency that produced the base map(s)

1.5.2 Name(s) of the base map(s) on which the geologic data have been plotted

1.5.3 Scale of the base map(s)

1.5.4 Edition of the base map(s) including the year of publication

1.5.5 Projection of the base map(s)

1.5.6 State Plane Coordinate System for the area of the base map(s)

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[1] Federal map accuracy standard and subsequent standards for base map representation.

These base map data are part of the metadata file that accompanies a digital geologic map. Other base map information are included in the digital metadata file, such as grid coordinate system, Universal Transverse Mercator (UTM) grid system and zone, and State Plane Coordinate System applicable to the map (see Section 1.6.1).

Other information regarding the base map must be provided on either tradition map copy or in digital map files. This information includes the:

1.5.7 Scale of the base map, represented by a ratio and by bar scales in metric and U.S. customary units

1.5.8 Altitude datum name and year

1.5.9 Magnetic declination of the map, and if the map is 30' longitude long or longer, the variation of magnetic declination from east to west across the sheet

1.5.10 In regions of the Nation covered by a cadastral land grid, the land grid must be clearly represented in the map area

All earth science maps, whether presenting primary data or derivative data, whether a separate map sheet or an illustration in an article, must be referenced to latitude and longitude, so that a map user can spatially relocate the map area.

1.6 INDEX TO MAP RELIABILITY

The increasing demand for readily available digital geologic map information, together with the rapid compilation of maps of large areas, is leading to a loss of primary information regarding the accuracy and extent of geologic map data and the positional reliability of contacts, faults, and point data on digital maps. Preparation of some geologic maps by conventional techniques has not preserved accurate positional representation of data: Distinctions of positional accuracy of lines by different line continuities are blurred at intermediate scales or are lost when continuous solid lines are used at large scales in the interest of economizing cartographic time. This standard includes the principle that geologic maps prepared at a scales of 1:250,000 and larger will include an index map showing the reliability of geologic mapping information. The index map summarizes the methods of mapping, the density of observations for the map area, and as appropriate, the areas of mapping responsibility of different contributing geologic mappers. The reliability index map will provide a visual summary from which the map user can assess the extent, detail, and general usefulness of the map information. The reliability index map will assist in identifying localities or areas within the map boundaries where other data need to be collected during subsequent studies to resolve specific geologic problems. This visual summary, together with those from other geologic maps, would be incorporated in the source and reliability indexes for all subsequent maps that use the primary map information.

Three factors are described on the reliability index map: (1) the methodology or methodologies applied during collection of the map data; (2) the density of data expressed in

terms of traverse spacing, spacing of observation points, or spacing of ground observations used to calibrate mapping from remotely sensed images; and (3) areas of mapping responsibility on multi-authored maps. The author or compiler of the geologic map defines the parameters used on the reliability index. Guidance is provided here through examples of content.

Different methodologies applied in making geologic maps affect the content, density of data, and positional accuracy of a geologic map. Historically, most geologic maps have been made by traverses on foot. The spacing of the traverses is determined by factors such as the purpose of the investigation, the intended scale of the final geologic map, and the terrain, thickness of vegetative cover, and land access. Traverses for reconnaissance-level maps often follow routes of ready access, including road and trails. In these cases, the geologist commonly interprets the geology from aerial photographs or other remotely sensed data for areas between access routes. In yet other cases, particularly in areas of rugged terrain, geologic observations are made from helicopter or light aircraft; ground control comes from site examination where the helicopter can land or from nearby areas accessible by wheeled vehicle or by foot. The reliability index map displays the general spacing of traverses and observations made and the method or methods of access used in mapping the overall area.

The method used to determine location during a geological investigation affects the positional accuracy of information on the map. To determine location of an observation, geologists commonly apply one or more of several techniques, including: (1) location by inspection on an aerial photograph. Locations and information mapped on the photograph are

subsequently transferred to the base map by stereoscopic optical plotter, by inspection, or other means. (2) Position is identified as the geologist compares the local details of physiography and (or) culture displayed on the base map with the actual physiography and (or) culture at the observational site. This general category would include measurement of distances along a road traverse with the vehicle odometer combined with inspection of physiography and (or) culture on the base map. (3) Position is located by one or more common surveying techniques, such as instrument resection or triangulation (conventional optical or laser instruments) from visible control points or by tape and compass measurements from control points. (4) Position is identified by application of a global positioning system (GPS). The GPS provides highly accurate locations, in cases exceeding the accuracy of the base maps, and enables the geologist to produce quickly in the field digital files of both position and geologic information at the observation site. Although during the time the standard has been prepared, GPS is not widely used in geological mapping, the method will soon become standard for determining position during geologic mapping. Methods 3 and 4 yield the most accurate positional information for geologic field data.

The technique(s) used to determine position, in combination with description of the spacing of the observations and access, is distinguished on the reliability index map. The index is a scaled graphic representation of the areas in which defined techniques and spacing have been used in mapping. For example, if geologic mapping of an area for a 1:24,000-scale map is performed by foot traverse at a general interval of 0.3-0.5 km using GPS, the index to map

reliability might be expected to be high; one pattern would represent that area on the index map (Fig.1.6.1). If another part of the area were mapped and positions were recorded by inspection

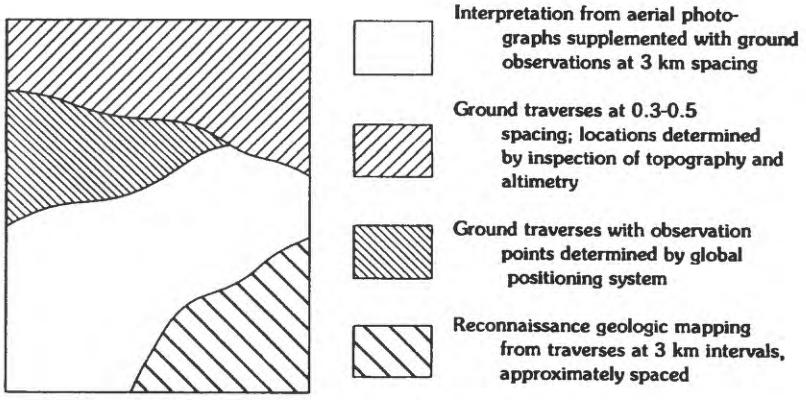


Figure 1.6.1. Geologic mapping reliability diagram of the Xenon quadrangle showing geologic mapping methods and approximate spacing of ground traverses and observation points.

on aerial photographs, the positional accuracy of the data might not be as high as that from ground traverses. A second pattern would represent the method of determining position and recording data on aerial photographs. Figure 1.6.1 illustrates a reliability index map for a geologic quadrangle map in which four mapping methodologies have been applied. As data collected by application of the different methodologies are consolidated on a common map, the index preserves a general record of the differences in data density and positional accuracy.

The reliability map can be combined conveniently with areal authorship responsibility on a single map (Fig. 1.6.2). Similarly, authorship credit for parts of a compilation map can be represented on a common index map with the surveying methodology. Compilers should make every attempt to determine the method of surveying and density of information for map sheets

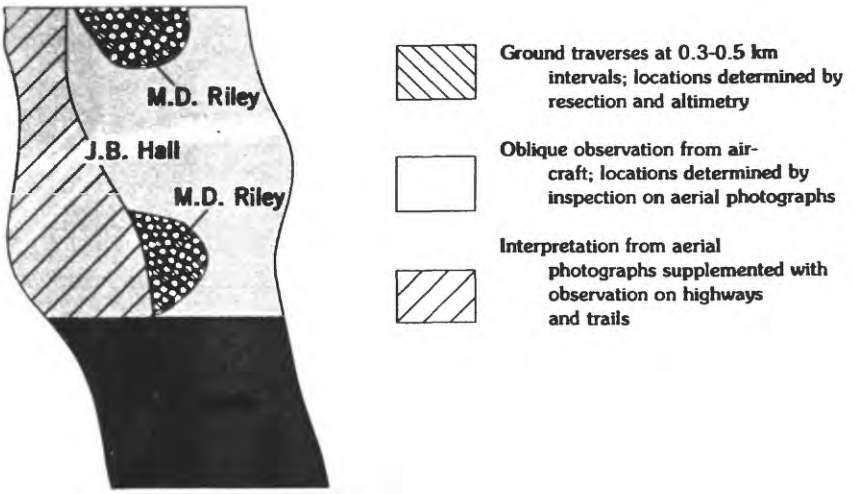


Figure 1.6.2. Reliability index map of the Rugged Ridge area showing geologic mapping methods, approximate spacing of ground traverses and observations, and mapping responsibility by author (shown by patterns).

incorporated in a compilation to begin preservation of the linage of map information. Figure 1.6.3 illustrates the further combination of a reliability index map with a map showing the published sources of information incorporated in a map compilation.

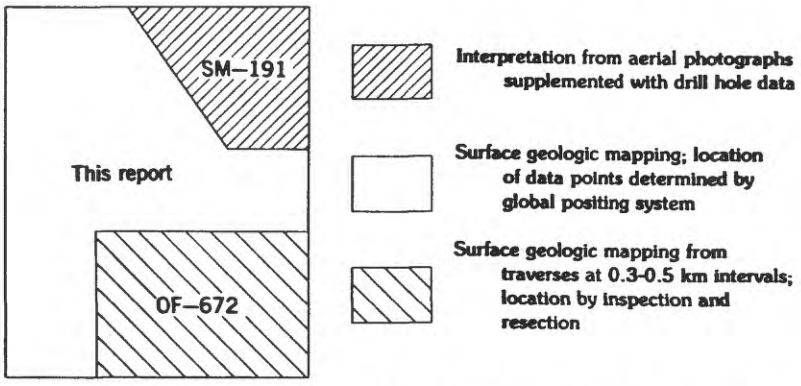


Figure 1.6.3. Reliability diagram of the Plano area showing sources of geologic map information, methods of geologic mapping, and approximate spacing of data and traverses.

The graphic representation of information on the reliability index should follow several guidelines; these guidelines are flexible to permit a design of as clear and visually attractive an index map as possible. Information pertaining to the density of traverses and data and method of access and positioning should be shown in varying line patterns. In general, the more open the pattern, the more widely spaced the data and lower the positional accuracy of line on the map. An unpatterned area or broadly spaced lines should be used for an area of least data and the least accurate positioning. Patterns with the highest concentrations of lines should be used for areas of the highest number of data and highest positional accuracy. On colored maps, different colors can be applied to the areas of different reliability. Stipple patterns of different densities can be overprinted to identify areas mapped by each author of a multi-author map, or to identify the different published and unpublished sources from which a map has been compiled.

The reliability index map on a geologic map should enable a user to assess readily the methodology used in mapping, the density of data and the relative accuracy of positional information on the map. As important, the reliability index map will help preserve knowledge of the accuracy of the geologic information both during digitization and during subsequent analysis and application of the geologic information.

1.7 SPECIAL-PURPOSE INDEX MAPS

For many areas, the amount of earth science information applicable to understanding and interpreting data for the area shown on a geologic map at a scale of 1:24,000 to 1:100,000 exceeds the space available on the map or cannot be shown at the scale of the map. Information such as the sources of geologic information used in compiling the map, the geologic setting, including the regional tectonics or regional rock facies, or the geographic setting of the map area may be essential. Other supplementary information such as sample localities, syntheses of geochemical information, and distribution of radiometric age determinations for rocks within the area enhance the usefulness of the primary geologic map. Whenever such information is essential and space permits, it should be included with other explanatory information in the margin of the primary geologic map on one or more special-purpose index maps.

Supplementary special-purpose index maps must meet the following standard:

1.7.1 The index map must show latitude and longitude for the area displayed.

1.7.2 All data within the area of the small-scale special purpose map must be referenced spatially and accurately by latitude and longitude.

1.7.3 The map must include a scale and an explanation for lines, symbols, patterns, or abbreviations used on the index map.

1.7.4 If the special-purpose index map covers an area larger than the geologic map, the index map must show clearly the area of the primary geologic map. That area may be shown by different weights or continuities of bounding lines, or by shading or color overprint, or by a combination of the methods.

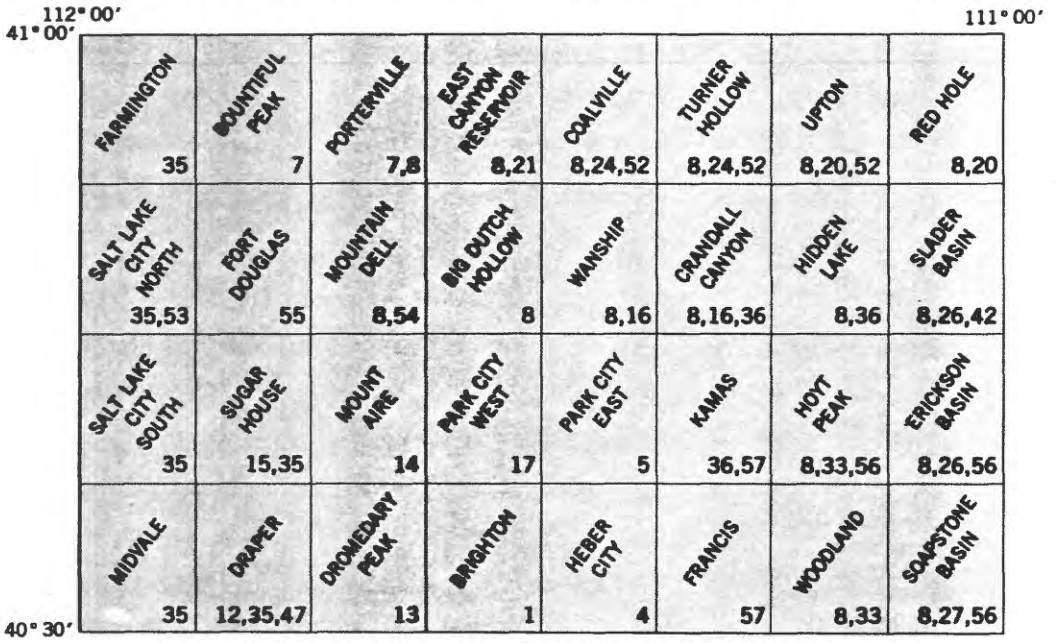
1.7.5 Principal topographic or cultural features that will help orient the map user to the region should be shown. Features such as principal rivers or water bodies, significant communities, towns or cities, county lines, highways, or outlines of major land-management areas may be shown, depending on the scale of the index map and providing that the detail does not compromise the purpose and legibility of the index map. The features may be shown with screened type or patterns, or in a screened color on a multicolor map.

The following list of special-purpose index maps illustrates some of the map types that have been used to supplement information on the geologic map. Generally only one or two such special-purpose index maps accompany a published geologic map; however, some published maps at 1:100,000 scale have as many as four small-scale index maps illustrating specific regional information.

Index map showing sources of geologic data used in compiling the geologic map. *Such an index map, together with the list of references for the data used, must be provided on any geologic map that incorporates data from other authors.* This index map may be combined with the geologic map reliability index (Section 1.6). Different line weights and line continuities, patterns, colors, and screens, or a combination of these, may be used to ensure legibility of the combined map information.

Index to 7.5-minute (or other scale) topographic maps in the region including the map area. Such an index map, as appropriate, may be combined with an index showing

Index to 7.5-minute (or other scale) topographic maps in the region including the map area. Such an index map, as appropriate, can be combined with an index showing sources of geologic data used in compiling the geologic map and(or) with the index to geologic map reliability. Figure 1.7.1 illustrates an index map which combines an index to sources of geologic data and an index to topographic maps in the region.



INDEX SHOWING MAJOR SOURCES OF GEOLOGIC DATA

(Numbers refer to entries in sources of geologic data)

SOURCES OF GEOLOGIC DATA

[Sources marked by asterisk are shown in index]

*1. Baker, A.A., Calkins, F.C., Crittenden, M.D., Jr., and Bromfield, C.S., 1966, Geologic map of the Brighton quadrangle, Utah: U.S. Geological Survey Geologic Quadrangle Map GQ-534, scale 1:24,000.

2. Best, M.G., Henage, L.F., and Adams, J.A.S., 1968, Mica peridotite, wyomingite, and associated potassic igneous rocks in northeastern Utah: American Mineralogist, v. 53, nos. 5-6, p. 1041-1048.

3. Bradley, M.P., unpublished mapping.

*4. Bromfield, C.S., Baker, A.A., and Crittenden, M.D., Jr., 1970, Geologic map of the Heber quadrangle, Wasatch and Summit Counties, Utah: U.S. Geological Survey Geologic Quadrangle Map GQ-864, scale 1:24,000.

*5. Bromfield, C.S., and Crittenden, M.D., Jr., 1971, Geologic map of the Park City East quadrangle, Summit and Wasatch Counties, Utah: U.S. Geological Survey Geologic Quadrangle Map GQ-852, scale 1:24,000.

6. Bromfield, C.S., Ericksen, A.J., Jr., Haddadin, M.A., and Mehnert, H.H., 1977, Potassium-argon ages of intrusion, extrusion, and associated ore deposits, Park City mining district, Utah: Economic Geology, v. 72, no. 5, p. 837-848.

Figure 1.7.1. Special-purpose index diagram showing the names of 7.5-minute quadrangles in the 30′x60′ map area. Also given are reference numbers to the sources of geologic data that were used in compiling the geologic map. Segment of text from map explanation gives example of sources of geologic map information that are referenced by number to the index.

Location and regional tectonic setting

Locality map of major geologic features

Locality map of major geographic (or physiographic) features

Generalized tectonic map of the area (Figure 1.7.2) or region of the geologic map

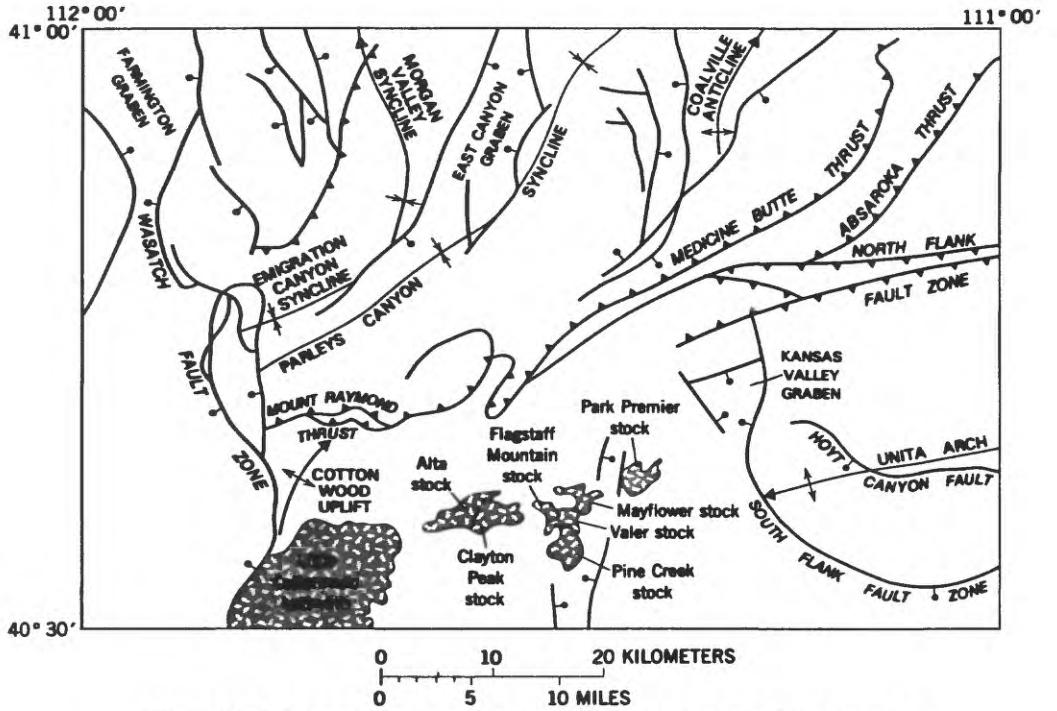


Figure 1.7.2. Special-purpose index map. A summary tectonic map showing major folds, faults, and intrusive igneous rocks in the 30′x60′ geologic map area. The index map shows the area in figure 1.7.1.

Generalized geologic maps showing principal structural features

Simplified geologic and mineral resource potential map

Generalized map showing the distribution of hydrothermal alteration in the map area

Generalized map showing the distribution of intrusive and (or) extrusive igneous rocks in the map area, together with locations and ages of rock samples dated radiometricially

Generalized map showing the extent of glaciation and (or) principal regional glacial features

Generalized map showing regional shorelines [marine or lacustrine, ancient (showing age designation) or modern (showing year)]

Generalized map showing thrust faults and thrust plates in the map area

Generalized isopachous or structure contour map (small scale) of map unit. Such a map may be appropriate for a 1:100,000-scale geologic map but, because of generalization of the contours, is rarely applicable to a larger scale map such as 1:50,000 or 1:24,000.

When considering the inclusion of a special-purpose index map on the geologic map, the principal criterion is that the index map must provide supporting information essential for the user to understand and apply the primary geologic map information. All information shown on the special-purpose index map must be clear, unambiguous, and explained either in the caption or in an explanation for the index map.

1.8 STANDARD FOR GEOLOGIC UNIT AND INFORMATION REPRESENTATION

This section establishes the standard for (1) the nomenclature of geologic units shown on maps, (2) the age designation of units, and (3) the content of citations to geologic information drawn from other publications for use on a geologic map. The standard for each of these elements derives from existing separate authorities or sources; the separate authorities are adopted here to guide use on all geologic maps.

1.8.1 Stratigraphic Nomenclature

Stratigraphic nomenclature used on geologic maps must conform to the North American Stratigraphic Code (North American Commission on Stratigraphic Nomenclature (NACSN), 1983, and subsequent modifications or revisions). In practice, conformance means that all formal units used on the geologic map must have been previously defined in accordance with the Code and are used on the map in a format consistent with the Code. Under provisions of the North American Stratigraphic Code, definition of a formal rock unit requires detailed information about the unit: its rank, origin of the proposed name, stratotype, character, stratigraphic relations, age, correlation, geographic extent, and other information (NACSN, 1983, p. 851). Rarely can such extended information be given on a geologic map. Thus, the Code does not provide for definition of new formal units on geologic maps [NACSN, Art. 4, note (7), p. 852]. From time to time, some organizations have granted exceptions to the Code to permit naming formal units on a map. However, in view of the general lack of space on a geologic map sheet and the current decidedly uneven content, production quality, and availability of digital geologic maps,

the "Cartographic and Digital Standard for Geologic Map Information" prohibits the naming of new formal stratigraphic units of any character or rank on geologic maps of any format.

Informal units may be used on a geologic map as long as several provisions are followed. Terminology applied must follow guidelines for informal units in the Code (NASCDN, p. 850-851), and the nomenclature must be unambiguous and consistent in identifying a mapped unit as informal. The rock type of an informal unit is never capitalized. A term of stratigraphic rank, regardless of capitalization, must not be assigned to an informal unit. The name of a formal geographic locality may be used in association with an informal unit; however, for clarity on both the correlation and the description of geologic units on a map, the locality name should follow the rock name, such as in granite of Boulder Peak or sandstone of Bents Corner. An informal unit, previously defined by a different author, may be used again as an informal unit, provided that the original author's name and year of publication are provided with the rock type [such as tuff of Sargent (1964)] and the citation to that author's use is provided in the list of references on the map.

1.8.2 Geologic Time and Ages of Rock Units

Several published schemes of geologic time boundaries are in use: Harland and others, 1982; Palmer, 1983; Snelling, 1985; U.S. Geological Survey *in* Hansen, 1991. Each of the schemes is based on different assumptions, techniques, and data. Any formally published scheme may serve as the basis for time boundaries applied to units on a geologic map. The author or compiler of a geologic map may follow a preferred scheme but must specify on a map note what scheme is used.

The "Cartographic and Digital Standard for Geologic Map Information" specifies the printed map symbols to be used for the ages of rock units (Section 2.35). The symbols are applied to the named age interval in accordance with the geologic time scheme used for the map. For example, if an author applies the Palmer (1983) scheme and a mapped unit falls in the Miocene Epoch as defined by that scheme, the map author uses the age symbol Mi for the unit. If, however, the unit falls within the boundaries of the Pliocene Epoch as defined by the Snelling (1985) scheme and applied by the map author, the author assigns the age symbol Pb. A map author or compiler must ascertain that (1) the age designations of rock units, as determined by cited radiometric or paleontologic determinations, (2) the named age [era, period (and system), and epoch (or series)], and (3) the limits of braces designating age intervals on the correlation of map units diagram are accurate and mutually consistent on all elements of the map.

1.8.3 Citation of References

A geologic map must include references to published and unpublished sources from which information included on the map has been derived (map element 1.1.3.5, references cited, Figure 1.1). Bibliographic citations for articles or books must follow the style adopted by most earth science agencies and professional organizations (such as in Hansen, 1991, p. 234-241). Citations for maps contain the same general information as articles and books, but the "Cartographic and Digital Standard for Geologic Map Information" requires additional information in order to facilitate computerized information exchange for both the original map and the referenced maps.

Upon release and subsequent adoption of this geologic map standard, the required elements of bibliographic citations for geologic maps used on another map include a combination of basic elements defined in "Anglo-American Cataloguing Rules," (Gorman and Winkler, 1988);

"Cartographic Materials" (Stibbe and others, 1982), and "Cartographic Citations–A Style Guide" (Clark and others, 1992) and used in the Library of Congress U.S. Machine Automated Reference Catalog (USMARC) system. The elements required here are not an extended list needed for full cartographic cataloguing; rather the standard includes elements that facilitate information exchange for the map user.

In sequence, the required bibliographic elements for map citations, showing the punctuation following each, are:

Author(s) name: last name first, followed by initials (or single name written out),

Year of publication or release (a critical element for all maps regardless of the format of release),

Map title:

Name of organization or agency publishing or releasing the map

Map series name and map number in the series,

Map scale, expressed as a reference fraction (for example, 1:24,000 or 1:62,500) (if the original map has only a bar or rake scale, that scale must be converted to a reference fraction for citation),

Longitude (westernmost extent of map–easternmost extent) and latitude (northernmost extent–southernmost extent) (for example, W111°00'00"–110°00'00"/N40°00'00"–39°30'00"),

State, county, and (or) region (if not included in the title),

Map format [in brackets], such as,

Electronic file. Provide format such as computer diskette, computer cartridge, CD-ROM, or computer map; name of cartographic

program, size of the map file(s) in units of bytes, and plotter format (optional)

Printed single sheet (or, for example, 2 sheets or 4 sheets). If a pamphlet accompanies the map, state "and pamphlet"

Printed map in pocket of a report. Title of the report, as well as the map title (above), must be provided in proper bibliographic style with plate number of the map

Illustration in a report. Title of the report, as well as the map title (above), must be provided in proper bibliographic style with illustration number and page number(s) of the map. Note: for a report illustration to be cited as a map, the original illustration must show longitude and latitude and a scale. If it does not, the illustration must be cited as a diagram

Manuscript map (photographic, xerographic, or other reproduction format of an unpublished map by the author cited).

Selected examples of citations that meet this standard are:

Lapp, E. T., and Stanley, R. S., 1986, Bedrock geology of the Mt. Grant–South Lincoln area, Central Vermont: Vermont Agency of Environmental Conservation, Office of the State Geologist, Special Bulletin no. 7, scale 1:11,647, W72°58'10"–72°54'53"/ N44°04'02"– 44°11'26" [printed, 3 sheets and pamphlet].

Turner, R. M., and Bawiec, W. J., digital compilers, 1991, Geology of Nevada: A digital representation of the 1978 Geologic map of Nevada: U.S. Geological Survey Digital Data Series DDS-2, scale 1:500,000, W120°00'–114°00'/N42°00'–35°00" [computer disc].

Weiss, M. P., Witkind,, I. J., and Cashion, W. B., 1990, Geologic map of the Price 30' x 60' quadrangle, Carbon, Duchesne, Uintah, Utah, and Wasatch Counties, Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-1981, scale 1:100,000, W111°00'00"–110°00'00"/N40°00'00"–39°30'00" [printed single sheet].

Yerkes, R. F., and Campbell, R. H., compilers, Preliminary geologic map of the Canoga Park 7.5-minute quadrangle, southern California, a digital data base: U.S. Geological Survey Open-File Report 95-90, scale 1:24,000, W118°37'30"–118°30'00"/N34°15'00"–34°07'00", Los Angeles County [computer map; Arc/Info, 150 MB].

References Cited in Section 1.1–8

Clark, S. M., Larsgaard, M. L., and Teague, C. M., 1992, Cartographic citations–A style guide: Chicago, American Library Association, Map and Geography Round Table, 23 p.

Gorman, Michael, and Winkler, P. W., 1988, Anglo-American cataloguing rules (2nd ed.): Chicago, American Library Association, 677 p.

Hansen, W. R., ed., 1991, Suggestions to authors of the reports of the United States Geological Survey (7th ed.): Washington, D. C., U.S. Geological Survey, 289 p.

Harland, W. B., and others, 1982, A geologic time scale: Cambridge, England, Cambridge University Press, 131 p.

North American Commission on Stratigraphic Nomenclature, 1983, North American stratigraphic code: American Association of Petroleum Geologists Bulletin, v. 67, no. 5, p. 841-875.

Palmer, A. R., 1983, The Decade of North American Geology 1983 Geologic Time Scale: Geology, v. 11, no. 9, p. 503-504.

Snelling, N. J., ed., 1985, The chronology of the geological record: Geological Society of London, p. 261-266.

Stibbe, H. L. P., Cartmell, Vivien, and Parker, Velma, eds., 1882, Cartographic materials–A manual of interpretation for AACR2: Chicago, American Library Association, 258 p.

1.9 GUIDELINES FOR THE PLACEMENT OF TYPE ON GEOLOGIC MAPS [1]

1.9.1 GENERAL ADVICE

One measure of the quality of an illustration is the uniformity of type placement. Legible type placement makes the illustration usable, but uniform type placement makes the usable illustration one of quality.

Each name and each symbol must be placed in order to assure immediate and unmistakable identification of the feature, as well as minimum interference with other map detail. Whether accomplished by hand or by computer, the positioning of lettering and the placement of symbols require care, judgement, planning, a knowledge of map composition, and an understanding of proportion and balance.

Quality illustrations result from the consistent treatment of proper type placement, letter spacing, and word spacing during preparation, as well as avoidance of type and line overprints and other interference with map detail. As a result the map information that is being presented will be grasped more readily by the reader, and the maps or illustrations will certainly provide a better understanding of the author's data and ideas.

These instructions are based on longstanding cartographic practices that were developed by careful analysis and application. They have been tried by time through use on map

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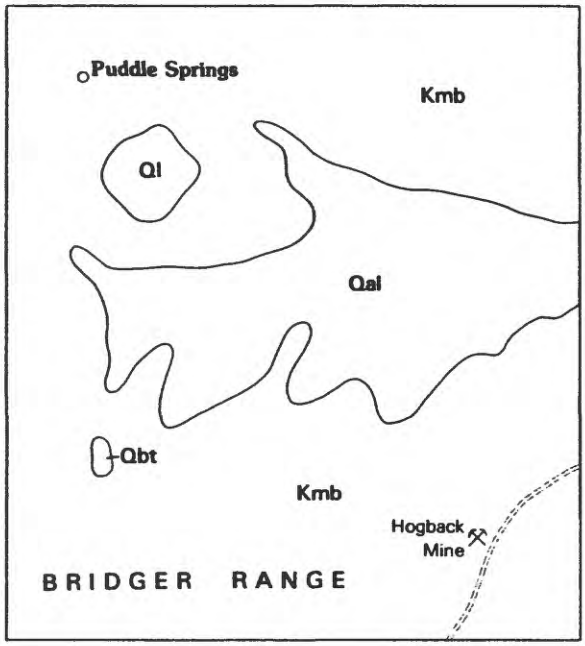
[1]Adapted from "Placement of Type on Geologic Maps," by Neil W. Maxfield, originally published in the Instruction Series of the Branch of Technical Illustrations, Publications Division, U.S. Geological Survey.

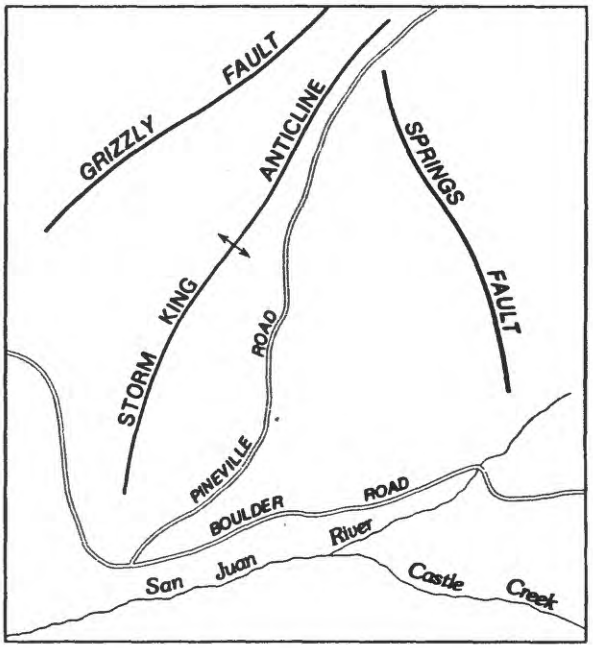
illustrations of the highest quality. The principles are valid for map illustrations that are prepared either by manual (traditional) or by electronic (computer) cartographic methods.

1.9.2 PREFERRED TYPE PLACEMENT



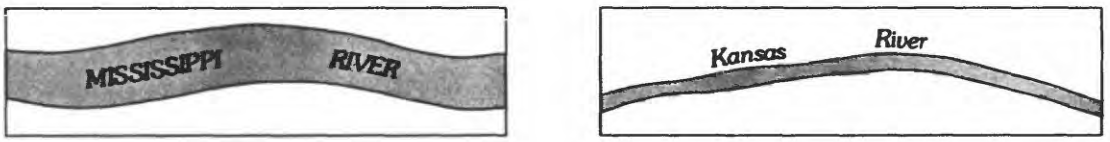
A map is read normally so that north is at the top of the map; therefore, most names and labels should be positioned parallel to the south neatline, as shown above. The exception to horizontal lettering is the labeling of diagonal linear features such as faults, anticlines, streams, and roads.

1.9.2.1 LINEAR FEATURES

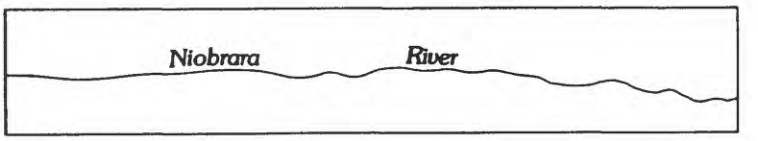


When labeling a diagonal linear feature, the type should read from south to north but should not appear to be tipped over backward. Linear labels should be positioned along an imaginary smooth line, even if the feature being labeled is curved or extremely crooked. The example above shows how names of streams, ridges, valleys, anticlines, synclines, and faults should be curved and the letters spaced to run along linear features. Position the labels 0.5 mm from the feature.

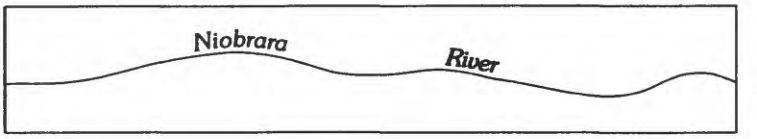
1.9.2.2 RIVERS AND STREAMS



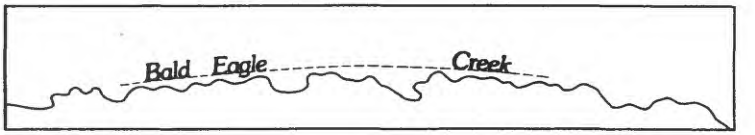
The name of a double-line stream is placed within the shoreline of the feature where space permits. Type must be placed entirely within or entirely outside the shoreline of the stream. Type placement above the stream is preferred to placement below the stream.



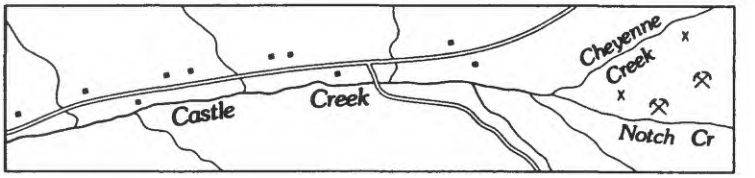
Stream names should be arranged in a smooth line, or curve, above the stream and within the center one-third of the length of the stream.



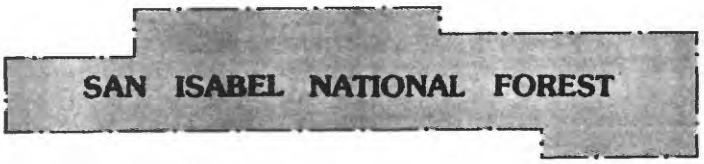
Stream names should be placed at a consistent distance (generally 0.625 mm) from streams and should be positioned in order to avoid compound curves in the type.



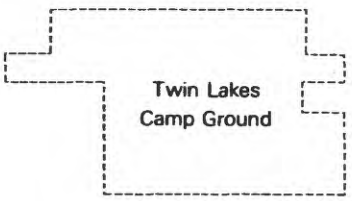
If the stream being labeled is extremely crooked, the stream name should follow the general direction of the stream. This technique avoids placing type to fit around compound curves and prevents unsightly changes in the direction of type.



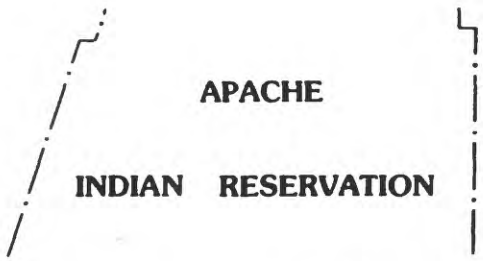
If a label is necessary on the underside of a stream in order to avoid interference with map detail, all components of the name should be placed on the underside. If space does not permit, a short stream name may, as a last resort, be broken so that part of the name is above the line and the remaining part is below the line. The words "River" and "Creek" may be abbreviated only as a last resort. Do not show periods if forced to abbreviate.



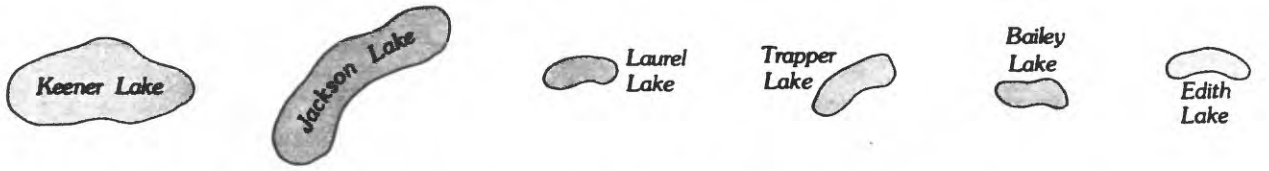
If the area is large enough, the lettering is placed within the boundaries of the feature, preferably centered and in one line.



If the name consists of two or more words, the lettering may be placed in two lines. This depends upon the length of the name and the size and shape of the area. Lettering should not be shown in more than two lines unless the type will fit in no other way.

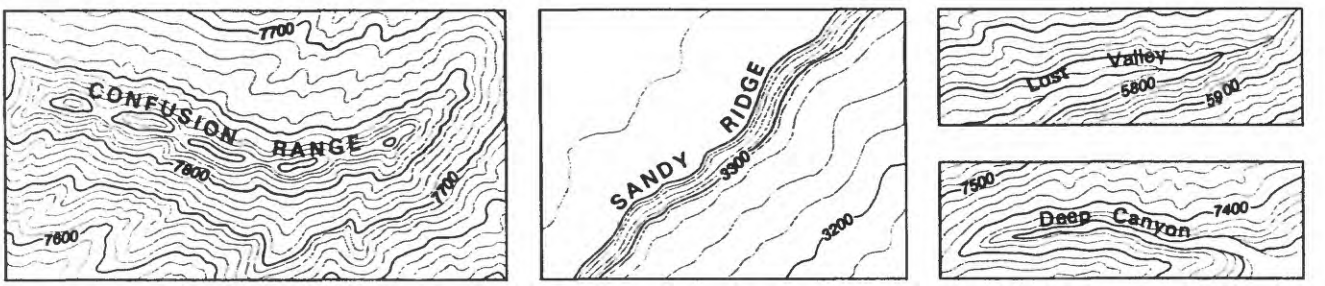


Where area names are placed in two lines, the vertical separation between lines of type should not be greater than (1) one-third of the length of the longer line of type or (2) the length of the shorter line of type, whichever is less.



Names of lakes, reservoirs, ponds, and swamps are oriented horizontally and are placed within the limits of the feature if its area is large enough. If space does not permit, the type may be placed to the right, left, top, or bottom of the feature, in that order of preference. When placing two or more lines of type to the side of a feature, align the type vertically on the side away from the feature and try to contour the type to fit the side of the feature. When placing two lines of type above or below the feature, center the second line beneath the first.

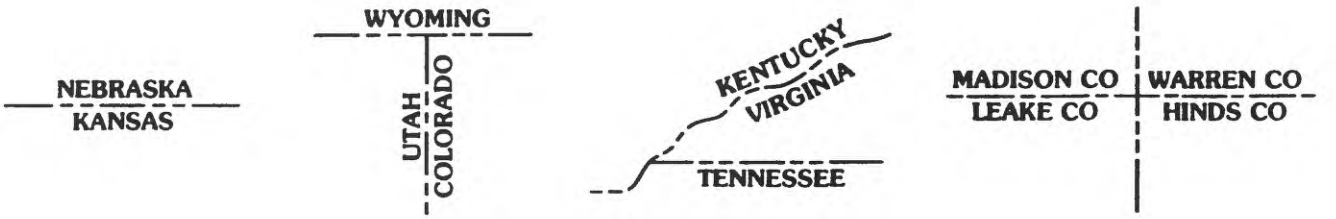
Names of large cities, civil townships, forests, parks, and reservations normally are placed horizontally near the center of the feature.



The name of a long, narrow ridge or mountain should be placed slightly to the north of the axis of the feature, should be clear of the top contour lines, and should be aligned on the general trend of the feature. If no contours are shown, the name should be positioned

along the axis of the feature. The name of a narrow valley, canyon, or gorge is placed on the north side and follows the general trend of the feature.

Type that identifies an area or a broad feature does not provide the immediate visual identification that it does for a linear feature. It does not have a line to help the reader associate the words with the feature. Therefore, the words must not be too widely separated. In order to facilitate immediate identification of the complete name of an area or a broad feature, the space between words in the name should not be greater than the length of the longest word.



Where names of States and counties are placed along and parallel to boundary lines, they are centered one over the other wherever practical.

1.9.2.4 POINT AND SPOT FEATURES

Type that identifies a point or spot feature, such as a school, peak, drill hole, or well, is placed commonly on two lines. The vertical spacing between the two lines of type should be normally about one-half the height of the lettering used.

The names of small towns, villages, and places are placed horizontally and, wherever practical, to the right of the feature symbol.

The preferred type placement for labeling small features or symbols, such as those above, is to the upper right. However, avoid placing type in alignment with small symbols where the symbol could be read as part of the lettering (036). The type should be placed 0,5 mm from the symbol.

If the placement of type to the upper right is impractical, the other positions that may be used are, in order of preference: lower right, upper left, lower left, centered above, and centered below. These are alternatives only and should not be used if type can be placed in the upper right position without interfering with other map detail.

The name of a small feature, such as a mountain peak, hill, gap, or pass, should be located to the right of its highest point.

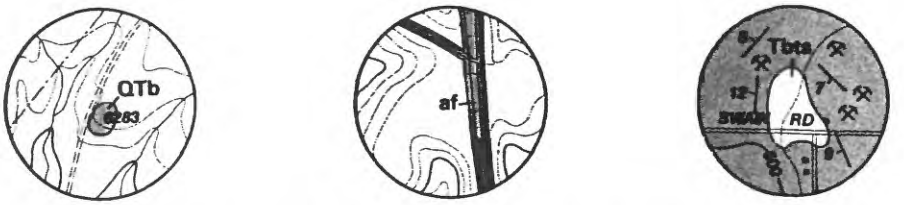
1.9.2.5 FORMATION SYMBOLS

Formation symbols should be placed far enough apart within large units so as to avoid duplication within a map user's immediate range of vision. However, coverage should be sufficient so that it is not necessary to search for the identification of the unit. Fewer formation symbols are needed on multicolor maps than on black-and-white maps because color will aid the reader in the identification of units. Multicolor maps that have good color contrast among units will require fewer formation symbols than those that have very little color contrast among units. Black-and-white maps commonly use several distinctive patterns in lieu of color to portray these units. If the map is black and white and has no patterned units, it may be necessary to label every area.

For small areas, the preferred placement of formation symbols is centered within the area. Some small colored areas are identified easily without labeling if the same formation is labeled nearby. If an overprint makes other map detail illegible, the symbol should be moved just enough from center to avoid the interference.

If overprints of lines are unavoidable in order to identify an area properly, choosing a contrasting line weight or color to be overprinted can minimize the interference. For

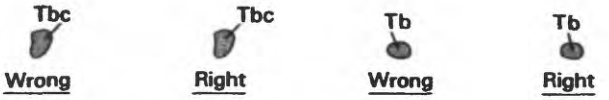
example, a thinner line weight or a light color under a formation symbol would be more appropriate for overprinting. Avoid using dark colors for large areas. If dark colors are used, they should be assigned only to small areas that can be labeled by the use of leaders. Where an area has a dark pattern that will obliterate a label, the pattern should be removed directly under the label.



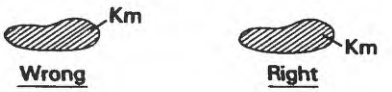
If formation symbols do not fit within the area to be labeled, place the formation symbol outside the area and add a leader from it to the area. Leaders should point from an imaginary dot in the center of the first or last letter of the symbol. If possible, leaders should be of uniform length (2.5 mm) and weight (0.2 mm) throughout the illustration. Leaders should be placed vertically only where it is not possible to add the leader at an angle. Vertical leaders should point from the center of the entire symbol.

A leader should cross the contact or fault line at nearly a right angle. If one is placed at exactly a right angle, it may be confused with a vertical dip; if placed too nearly parallel with the contact or fault line, it may not be readily identifiable as a leader. One-third of the leader should be inside the area that is being labeled, unless a long leader must be used. Long leaders should be avoided but rarely may be used, especially on black-and-white illustrations where many formation symbols are essential.

Avoid the use of multiple leaders, especially in multicolor illustrations. Consider the color contrast among the areas being labeled and the surrounding area. If the contrast is easily distinguished, it not necessary to label each area. If little or no contrast exists among areas, additional formation symbols are preferred to additional leaders, unless the extra symbols would overcrowd the area.



Never use "back-leadering." A leader should connect the area and the nearest part of the lettering.

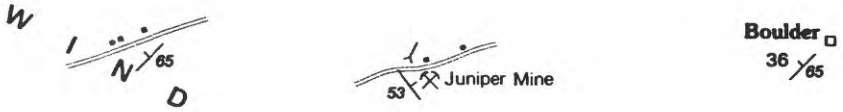


Never leader into a lined pattern in such a way that the leader runs in the same direction as the pattern or produces interference with the pattern.

Do not place lettering so that it can be read into the label of another feature. Check against other overlays or data layers and on the base map.

1.9.2.6 DIP AND PLUNGE VALUES

Numbers for the dip value adjacent to a dip and strike symbol should be placed so that the dip tick points to an imaginary dot in the center of the nearest number. Where dips are nearly vertical, the entire value should be centered off the dip. Departure from this rule is permitted only where necessary in order to avoid interference with other map detail. Except for values that must be moved slightly to improve legibility, a uniform space of 0.5 mm should be kept between dips and their values throughout the illustration. The same principles apply to numbers for plunge values or measurements recorded for other geologic surfaces or linear geologic features.



Placement of a dip value on the back side of the symbol is allowed only where placement of the value on the dip side would interfere with other map detail. If placing the value on the dip side is too far from the symbol to be easily associated with the symbol, it should be placed on the back side.

1.9.3 LETTER SPACING

The names of streams and other linear features normally have 1-point letter spacing. This spacing facilitates placement on curved and meandering lines. The exception to this rule would be the identification of large fault zones and other structural features, such as a large synclinal basin. These features would have much larger letters that may be spaced much farther apart, in

some cases as far as 12.7 mm apart. Likewise, if a ridge or valley name is too short to identify the feature properly, the spacing between the letters should be increased. However, the spacing between letters should not exceed four times the height of the individual letters.

1.9.4 WORD SPACING

Spacing between words helps to mark the extent of a named feature. A combination of word and letter spacing may be used to span extra large features, but the components of the feature name should not be placed so far apart that their relation is not immediately evident. For example, on a stream that is not long enough to justify placing the name on the map two times, the tendency is to spread the components widely in order to suggest the extent of the feature. This practice is justified only where the relation and sequence of the component parts are evident at a glance. On a long feature, it is preferable to repeat a name rather than spread it too far apart. For features of such length that two or more labels are necessary, a larger space should appear between the repeated names than between the words of one name set. This is particularly applicable to roads, railroads, and streams.

Words in a name are spaced equally unless a thought-unit relation exists between certain words. Less space should be allowed between related words than between words that are not related, as follows:

BIG ROCK FAULT
STORM KING ANTICLINE
Black Bear Mountain
San Juan River
North Fork Eagle Creek
North Fork Bald Eagle Creek

San Andres Limestone
Dewey Lake Red Beds
Central Basin platform
Burro Canyon Formation
Tiger Mountain basin
Little Beaver Ridge

R O C K Y M O U N T A I N S
ROUGH CREEK FAULT ZONE

The significance of the words must be considered in the proper placement of type, as in the following:

The name of this river is "Big Thompson."

The name of this river is "Thompson." This placement of type implies that there are two Thompson Rivers, this one being the larger.

The thought-unit relation between words should be maintained where it is necessary to place a name on two lines, as follows:

Crown Hill		*Crown*
	rather than	
Lake		*Hill Lake*

1.9.5 PUNCTUATION

For simplicity and uniformity and because no mark should be used that could be mistaken for a map symbol, most punctuation marks are omitted form the body of the map. A period is not shown, and an apostrophe is rarely used to indicate possession. Harpers Ferry and Pikes Peak syncline are the correct map forms, not Harper's Ferry or Pike's Peak syncline (Martha's Vineyard is a longstanding exception). The apostrophe is used only to denote a missing letter (Lake O' the Woods) or where it is part of the name (O'Brien Creek).

D R A F T

CARTOGRAPHIC AND DIGITAL STANDARD FOR GEOLOGIC MAP INFORMATION

PART 2. GEOLOGIC MAP FEATURES: SYMBOLS, GRAPHICAL STANDARDS, AND ATTRIBUTE CODES

2. GEOLOGIC MAP FEATURES: SYMBOLS, GRAPHICAL STANDARDS, AND ATTRIBUTE CODES

2.0 INTRODUCTION

Geologic map feature symbols and attribute codes in this standard are intended for use in the compilation and publication of geologic maps at scales ranging from 1:24,000 to 1:100,000; however, they can be applied also to maps at other scales. The standard provides definition and discussion of these symbols and codes in order to make common understanding explicit for application to traditional and electronic (digital) representation alike. The standard applies to all phases of map making, including field mapping and data gathering, compilation, digital plotting, and drafting.

The focus on scales between 1:24,000 and 1:100,000 and on general-purpose geologic maps has been adopted in order to reduce the number of elements to a manageable group, as well as to avoid expanding discussion at this first stage of standard definition to the special needs of very large scale maps such as mine maps, small-scale compilation maps, and special-purpose maps. As the standard is applied, additional standards will be developed for special-purpose earth science maps, including maps at other scales and maps presenting results of other methodologies such as geophysics and geochemistry.

In sequence, this section of the "Cartographic and Digital Standard for Geologic Map Information" provides the system and rules for attributed coding applied in this standard, together with cross references between codes and features and feature categories and codes. The geologic

map standard then provides a compendium of standard symbols for geologic map features including cartographic standards and specifications and the digital codes for the features.

Changes in features standards and coding may be required as the earth sciences develop or as new data become available. New symbols may be devised if those given in this standard prove to be inadequate or misleading. However, use of symbols published in this standard for features other than those specified as first or alternate usage should be avoided. Newly defined symbols and usages proposed for use in publications and for inclusion in the standard should be forwarded to the Geologic Map Standards Committee, Office of the Chief Geologist, U.S. Geological Survey, National Center, Reston, Virginia 22092, for evaluation and possible inclusion into the standard.

2.0.1 ATTRIBUTE CODING FOR EARTH SCIENCE FEATURES, 1:24,000 AND 100,000 SCALES

The attribute coding scheme adopted for this standard is based on major code–minor code pairs, like those used by DLG3 attribute coding for geographic data (U.S. Geological Survey, 1989, US GeoData, Digital line graphs from 1:100,000-scale maps, U.S. Geological Survey, National Mapping Program, Technical Instructions, Data Users Guide 2, 88 p.).

The major code defines the category of data. The associated minor code provides specific information about the data category. In the geologic map standard, major codes are three digit numbers and minor codes are four digit numbers. Although as many as 12 major–minor code pairs can be accommodated by some computer systems, attributes for most symbols and lines

require one or two pairs. A number of individual feature codes in this standard are defined by as many as four code pairs that are needed to define the feature and its attribute(s), as well as its orientation in space and special cartographic representation.

Geologic map data include not only areas, lines, and points but also information such as the names and ages of rock bodies (formations, key beds, and other units), structures, colors, thickness, geological engineering properties, dates of geologic events, or mineral, fossil fuel or natural resource content. Tables in row–column format (lookup table) are used, where needs dictate, in order to resolve issues like assigning numbers to the estimated 50,000 formal rock names, the plethora of informal units, and even more "units" formed by groupings of the formal units. Codes in this standard requiring use of a lookup table designate the table number (T) and the feature number (N) in the minor code for the feature.

2.0.1.0.1 Points represent point features, the intersection of lines, and the areas or intersections of volumes with surfaces too small to show as areas at map scale (degenerate lines or areas). Point elements on geologic maps are represented by symbols and or by alphanumeric characters. Most of the alphanumeric characters are used in sequences (words), and most are standard keyboard characters defined in the ASCII character set. Special problems are caused by special characters long-standard to general-purpose geologic maps but not to computer keyboards. Examples include the Triassic ℟, the Pennsylvanian ℙ, or the Cambrian ℭ. These characters are used in sequences with other letters, but the characters lack keyboard or screen representation on standard computer systems. Some systems can use extended ASCII characters (ASCII 129-255); others specify alternate fonts and redefine output for keyboard characters. A standard character

set for these characters is suggested here (Section 2.35). Implementation must be provided for inclusion in data bases that use the characters and graphic output but is left to system programmers.

2.0.1.0.2 Lines represent linear features, the intersection of surfaces, and areas or intersections of volumes with surfaces too small to show as areas at map scale (degenerate areas). Lines are digitized from intersection to intersection. They obey a "From-To" rule, in the sequence of points, if the direction of the line is important, as for example, to indicate flow direction along the line. A corresponding "Right-Hand" rule is in effect if a non-centrosymmetric decoration has been chosen to represent the feature, as for example for thrust faults, where the decorating symbol is plotted on the upper plate, and from digital files on the right-hand side of the line with direction from the first point to the last point.

2.0.1.0.3 Areas represent geometric areas at map scale and intersections of three-dimensional solids with surfaces.

2.0.1.0.4 Most entities represented in a digital data base will represent real-world features, some specific observations or feature geometry or spatial orientation, and others, general observations not associated with a particular place but required for representation. Not all graphic elements on a paper copy will be represented in the data base itself. For example, the teeth on a thrust fault will not be separately placed symbols but rather, a graphic consequence of the graphic representation of a thrust fault and the sequence of points (right-hand rule) for

decorating lines with symbols. Implementation to meet graphic standards for paper copy is a requirement of the software and hardware system using the data supplied. Feature points are represented by a point having attributes in a digital data base. The attributes are in part dependent on graphic conventions. Graphic conventions for digital definition of symbols that represent observations of the attitude of planar and linear features are provided below.

2.0.1.1 RULES FOR CODING FEATURE SYMBOLS

2.0.1.1.1 SYMBOLS REPRESENTING OBSERVATIONS OF PLANAR FEATURES

The point of observation and the index point for the symbol is at the midpoint of a line segment representing the strike and is drawn in the direction of the strike.

The general dip direction of the planar feature is indicated by a second graphic element of the symbol (such as a tick mark or arrow head) on the down-dip side of the strike line.

Symbols that portray the strike and dip of planar features obey a right–hand rule: From the point of observation, looking along the line of strike, the surface dips to the right.

The angle of azimuth is the angle between true north and the strike line (0-259 degrees). A planar feature with 0 degree azimuth dips to the east.

The angle of true dip of the surface is posted on the down-dip side of the strike line of the symbol.

2.0.1.1.2 SYMBOLS REPRESENTING OBSERVATIONS OF LINEAR FEATURES

The point of observation and the index point for the symbol is at the up-plunge of the line drawn along the trend of the linear feature.

The general plunge direction of the planar feature is indicated by a second graphic element of the symbol (arrow point) on the down-plunge end of the line that represents the trend of the linear feature.

The angle of bearing is the angle between true north and the projection of the linear on a horizontal surface line (0-259 degrees). A linear feature with 0 degree azimuth angle plunges north.

The plunge angle is the angle between the linear feature and the horizontal. Plunge angles are posted on the down-plunge (decorated) end of the symbol.

2.0.1.1.3 CONVENTIONS FOR GRAPHIC REPRESENTATION

The effects of these graphic conventions is that symbols for planar and linear features are rotated **clockwise** by the amount of the azimuth or bearing angle in degrees. Posted numbers representing the angle of true dip (planar features) or plunge (linear features) likewise change position relative to the point of observation, but the numbers themselves do not rotate.

Symbols representing observations of linear and planar features are normally represented by a single geodetically defined point: The point of observation is the index point of the

symbol. The nature of the observation, the amount of rotation to represent the line of strike or lineation, and the angle of dip or plunge are provided as attributes for the point.

To facilitate graphical representation, the following conventions are followed:

If the symbol is represented by a single digital point, the software system will place the angle of dip or plunge at a default position.

If the symbol is represented by two digital points, the second point defines the point for plotting of the angle of dip or plunge.

Label points are used principally for text (feature names) for feature identification. The location of the label point is at the location of the feature.

An area point is a point within an area carrying attribute information about that area. The location of the area point may be at any point within the polygon that defines the area, but not within an internal (therefore excluded) polygon.

2.0.1.2 ATTRIBUTE CODES: FIRST MAJOR CODE

The first major code is a three digit number **6nn**. It designates the earth science data layer and provides geometric characteristics of the features and the source of the supplementary data required for representation of the entity. A data element will have at least one major code and one associated minor code.

First digit:

0 Holds first code position to direct reference to second and third digits that define a feature and its representation and to the succeeding minor code that defines data pertaining to the feature

6 Earth science data layer

Second digit:

0 Point on the surface of the Earth
1 Point projected to the surface of the Earth
2 Point, degenerate line represented by symbol
3 Point, degenerate area represented by symbol
4 Line on the surface of the Earth
5 Line projected to the surface of the Earth
6 Line representing intersection of geologic surface with surface of the Earth
7 Line representing intersection of two geologic surfaces projected to the surface of the Earth
8 Line, degenerate area represented by line
9 Area

Third digit:

0 Used for features, definition requires no lookup table
1 Used for labels, either label symbols such as the symbol used on the trace of an anticline or labels composed of a few alphanumeric characters such as the "M" plotted near a fault defined by a ground magnetic survey; definition requires no lookup table.
2 Open for use for features to be defined; requires value (characters) from minor code
3 Definition of measurement: requires value (characters) from minor code. See symbols standard (reference number 2.1)
4 Open for use for features to be defined; requires value (characters) from minor code
5 Open for use for features defined; requires value (characters) from minor code

6 Definition requires value (characters) from lookup table. Used for isopleths

7 Definition requires value (characters) from lookup table. Used for features

8 Definition requires value (characters) from lookup table for applications of text labels. Examples include:

618 Definition requires value (characters) from lookup table. Used for test labels associated with a point; see Description in symbol standard (reference no. 2.1)

658 Definition requires value (characters from lookup table. Used for text labels to be plotted along a line; see Description in symbol standard (reference no. 2.1)

9 Definition requires value (characters) from lookup table. Used for area definitions, including lines that represent degenerate areas

2.0.1.3 ATTRIBUTE CODES: MINOR CODES

Minor codes as defined in this standard consist of four numbers that define the particular feature symbol or data pertaining to the feature to be represented on the map. Minor codes are defined for families or groups of symbols and are provided in Geologic Map Symbols (text section 2.1).

Examples:

660 0001	Major code:	6	Earth science data layer
		6	Line representing intersection of geologic surface with surface of the Earth
		0	Feature. Requires no lookup table
	Minor code	0001	Geologic contact

063 xxx	Major code	0	Holds first position in major code
		6	Intersection of geologic surface and surface of Earth
		3	Definition of angle measurement in horizontal (map) plane as value from succeeding minor code
	Minor code	0	Holds first position in 4-digit minor code
		xxx	Rotation in degrees clockwise (east) from 0 to 259 degrees. For angles 0-90 degrees add zeros in front of angle to fill 4-digit code
064 00yy	Major code	0	Holds first position in major code
		6	Intersection of geologic surface and surface of the Earth
		4	Definition of angle measurement in vertical plane as value from succeeding minor code
		00	Holds first two positions in 4 digit minor code
		yy	Rotation in degrees in vertical plane normal to strike, from 0 to 90 degrees. For angles 0-9 degrees, add one additional 0 to angle to fill 4-digit code

Abbreviations used in minor codes in Section 2.1 Geologic Map Symbols:

T	Number of a specific lookup table
N	Number of the entry in the lookup table
Y	Number of geologic unit in specified lookup table
00xx	Degrees azimuth measured clockwise from north
0yyy	Degrees downward from horizontal surface, measured in vertical plane
aaaa	Calendar (Julian) year
ffff	Number for line, thickness in feet
mmmm	Number for line, thickness in meters
nnnn	Reference number or measurement to be assigned to feature
vvvv	Overprint number from lookup table

2.0.1.4 ATTRIBUTE CODES: MULTIPLE ELEMENT TYPES

For major codes 600, 601, 602, and 603 used for points, the associated minor code is used to specify the kind of symbol. Additional major code–minor code pairs are used to specify the angle of rotation of a symbol (from north) and the angle (dip or plunge) to be posted at a position near the symbol (see examples, Section 2.0.1.3)

Major code 065 provides a way of dating a modern feature. The associated minor code aaaa provides the (Julian) calendar year. For example:

First order major–minor code	640 0072	Former shoreline (symbol reference no. 2.20.1)
Second order major–minor code	065 1989	
Major code	065	Refers to succeeding minor code for the year
Minor code	1989	Feature is dated as 1989

Multiple element types that require lookup tables. Information needed to complete the description of elements using major codes 67n, 68n, and 69n is supplied in a lookup table constructed for a particular data base, such as for map units, key bed, and mineral or fossil fuel commodities. The table is an ASCII table in standard format. For example:

First order major–minor code	698 000T	Key bed. T denotes lookup table number for map units

Second order major–minor code 071 000N Unit name. N denotes name from lookup table

Codes are provided for geologic features and measurements under **Code** column in Section 2.1. Coding is not provided for three categories of features in the symbols list: (1) symbols for geologic entities that are not referenced spatially on a map (for example, fossil symbols for stratigraphic columns, reference numbers 2.26.3 through 2.26.61); (2) some special symbols destined for intermediate- and small-scale terrestrial and planetary geologic maps (scales 1:250,000 and smaller); and (3) symbols for most hydrography categories (reference nos. 2.42-2.44, 2.45, 2.46, and 2.50-2.52), which are treated in standard documents for hydrographic features.

2.0.2 CODE-TO-FEATURE CROSS REFERENCE

The following table provides cross reference between codes and features of the Geologic Map Symbols (Section 2.1, reference nos. 2.1.1 through 2.36.6). Part 1 lists the codes in ascending order of major code numbers. Part 2 lists the codes in sequence by feature description: areas, lines, points, and descriptive elements.

CODE-TO-FEATURE CROSS REFERENCE

PART 1. CODE CROSS REFERENCE, BY CODE NUMBER

Code		Feature
060	0001	Approximately located
060	0002	Inferred
060	0003	Concealed
060	0004	Gradational
060	0010	Fault
060	0011	Sub-vertical fault
060	0012	Normal fault
060	0014	Reverse fault
060	0016	Strike slip fault
060	0017	Right lateral strike slip fault
060	0018	Left lateral strike slip fault
060	0019	Oblique slip fault
060	0020	Thrust fault
060	0024	Overturned thrust fault
060	0026	Detachment fault
060	0030	Fold, beds upright
060	0031	Overturned fold (beds on one limb overturned)
060	0032	Inverted fold (beds on both limbs overturned)
060	0040	Lineation, elongate minerals
060	0041	Lineation, streaked mineral aggregates
060	0045	Lineation, "B" lineation, parallel to minor fold axes
060	0046	Lineation, "A" lineation, parallel to slip direction
060	0048	Lineation, intersection of surfaces
060	0124	Location from aeromagnetic survey
060	0125	Location from ground magnetic survey
060	0126	Location from gravity survey
060	0128	Location from radiometric survey
060	0200	Dry hole, radial ticks at 0°, 90°, 180°, and 270°
060	0202	Abandoned well, diagonal line across well symbol
060	0204	Capped well, T symbol at top of well symbol
060	0205	Shut-in well, horizontal line through well symbol
060	0207	Show of oil
060	0208	Show of gas
060	0209	Show of oil and gas
060	0210	Well converted to water well, diagonal arrow across well pointing outward
060	0212	Injection well, inward-directed arrow
060	0213	Water injection well, point in center of well symbol
060	0214	Water input well, X symbol inside well symbol
060	0215	Salt water disposal, triangle symbol with ticks around well symbol

060	0351	Hazardous waste, direction of surface leachate flow from site
060	0352	Hazardous waste site, active, symbol fill
060	0353	Hazardous waste site, closed, vertical bar through symbol
060	0354	Hazardous waste site, cleanup in progress, half-fill of symbol
060	0355	Hazardous waste site, cleanup complete
061	0129	Horizontal bedding measured from aerial photograph, symbol
061	0130	Gently inclined bedding, measured from aerial photograph, symbol
061	0131	Moderately inclined bedding, measured from aerial photograph, symbol
061	0132	Steeply inclined bedding, measured from aerial photograph, symbol
061	0133	Vertical or near-vertical bedding measured from aerial photography, symbol
063	0xxx	Angle of rotation, clockwise (nearest whole degree
064	00yy	Angle of dip or plunge (nearest whole degree)
065	mmmm	Measurement in meters (value from minor code)
065	ffff	Measurement in feet (value from minor code)
067	0nnn	Feature of numbered type (value from minor code)
068	0001	Feature measured at point of coincidence with other features (digital symbol's index point is at end of strike line where symbol's strike lines intersect
070	0001	Graded bedding symbol, short dashes to go beneath strike line
070	0002	Graded bedding symbol, short dashes beneath strike line interrupted around overturned dip symbol
070	0003	Cross bedding symbol, arcs beneath strike line
070	0004	Cross bedding symbol, arcs beneath strike line interrupted around overturned dip symbol
071	000T	Entity of entry in lookup code, T is number assigned to entity
072	0___	For symbols, minor code indicates percent of standard size symbol
073	____	Minor code indicates size, 10 times point size (such as 60=6 points)
600	0001	Measurement of bedding, sedimentary rocks
600	0002	Measurement of bedding, contorted sedimentary rocks
600	0003	Measurement of bedding, approximate, sedimentary rocks
600	0004	Measurement of bedding, stratigraphic top direction known from local features, sedimentary rocks
600	0005	Measurement of bedding, overturned beds
600	0006	Measurement of bedding, overturned beds, stratigraphic top direction known from local features
600	0007	Measurement of bedding, beds overturned more than 180 degrees
600	0009	Minor fault, showing strike and dip
600	0010	Measurement of bedding from aerial photograph
600	0011	Foliation, layered gneiss
600	0012	Foliation, contorted layered gneiss
600	0014	Foliation, bedding, layered gneiss top known from local features
600	0016	Foliation, inclined parallel to overturned bed in layered gneiss; top known from local features
600	0018	Massive igneous rock
600	0020	Attitude of foliation and layering in igneous rock

600 0022 Flow foliation, approximate, contorted, igneous rock
600 0023 Cumulate foliation in igneous rock; vertical; top is known from local features
600 0024 Cumulate foliation, layering, igneous rock
600 0025 Cumulate foliation, layering, contorted, igneous rock
600 0026 Cumulate foliation, igneous rock, top known from local features
600 0027 Cumulate foliation parallel to overturned layering in igneous rock; top known from local features
600 0028 Compaction foliation, ashflow tuff
600 0029 Compaction foliation, approximate, contorted ashflow tuff

600 0030 Measurement of strike and dip on rock cleavage
600 0031 Measurement of strike and dip on vein
600 0032 Measurement of strike and dip on joint surface
600 0033 Axial surface minor fold, horizontal
600 0034 Axial surface minor antiform, inclined
600 0035 Axial surface minor anticline, inclined
600 0036 Axial surface minor overturned anticline,inclined
600 0037 Axial surface minor synform, inclined
600 0038 Axial surface minor syncline, inclined
600 0039 Axial surface minor overturned syncline, inclined
600 0040 Minor fold axis
600 0041 Axis, minor anticline
600 0042 Axis, minor syncline
600 0043 Axis, dextral minor fold
600 0044 Axis, sinistral minor fold
600 0045 Axes, minor folds. showing bearing and plunge

600 0050 Lineation, bearing and plunge, type undesignated
600 0051 Mineral lineation, bearing and plunge, (B lineation) on foliation surface
600 0052 Mineral lineation (A lineation), bearing and plunge, on foliation surface
600 0053 Lineation, slip feature [groove, striae, (A lineation)]x on foliation surface
600 0055 Linear flow feature, bearing and plunge, on flow foliation surface
600 0056 Minor fold axis defined by flow foliation
600 0057 Flow direction from pipe amygdules
600 0058 Mineral lineation, cumulate rocks, showing bearing and plunge
600 0059 Trough banding, cumulate rocks, showing bearing and plunge
600 0060 Lineation on compaction surface, ashflow tuff
600 0061 Lineation, minor folds normal to flow in ashflow tuff
600 0062 Lineation, intersection of bedding and cleavage, showing bearing and plunge
600 0063 Lineation, intersection of foliation and cleavage, showing bearing and plunge
600 0064 Lineation on cleavage surface, showing bearing and plunge
600 0065 Lineation, slip on fault surface, showing bearing and plunge
600 0066 Flow direction and plunge, basal surge, ash deposits (determined from bed forms of antidunes)
600 0067 Lineation, penetrative; used in combination with foliation symbol; lineation not in foliation surface; showing bearing and plunge
600 0068 Boudinage, showing bearing and plunge

600 0070 Arrow, showing direction and plunge; requires codes for direction of rotation of arrow and angle of plunge

600	0071	Ice molded land form (drumlin, drumlinoid form)
600	0072	Glacial striae, direction of glacial flow
600	0074	Glacial striae, direction of flow unknown
600	0075	Fluvial transport direction
600	0076	Fluvial transport direction from imbrication
600	0077	Fluvial transport direction from cross beds
600	0078	Fluvial transport direction from flute casts
600	0080	Sediment transport direction, determined from dune morphology
600	0081	Sediment transport direction, determined from cross bedding in vertical or near-vertical section
600	0082	Sediment transport direction, determined from dune bedding in horizontal or near-horizontal section
600	0100	Tick mark to indicate dip and strike of surface (e.g. contact, fault
600	0102	Arrow to indicate direction and plunge of measured linear feature on surface (e.g. contact, fault)
600	0104	Triangle symbol to indicate locality of observation
600	0139	Tick to indicate direction of dip crossover (Place where surface changes dip from one side to the other)
600	0151	Impact crater, symbol used for crater too small to outline at map scale
600	0152	Impact crater, primary
600	0153	Impact crater, secondary, formed by debris thrown up from primary crater
600	0200	Diamond drill hole
600	0220	Dry hole, hydrocarbon exploration
600	0222	Oil well
600	0224	Gas well
600	0226	Oil and Gas well
607	000T	Fossil locality; requires lookup table for locality and accession number
611	0020	Label A active or recently active earthflow, landslide
611	0022	Label D dormant earthflow, landslide
611	0024	Label DF Debris flow
611	0026	Label EF Earth flow
611	0030	Antiform, symbol on trace
611	0031	Anticline, symbol on trace
611	0032	Asymmetric anticline, symbol on trace
611	0033	Overturned anticline, symbol on trace
611	0034	Inverted anticline, symbol on trace
611	0035	Fold having vertical or near-vertical axis
611	0036	Synform, symbol on trace
611	0037	Syncline, symbol on trace
611	0038	Asymmetric syncline, symbol on trace
611	0039	Inverted syncline, symbol on trace
611	0040	Arrow to show direction of flow as label on flow lines
611	0041	Monocline (single trace). symbol on trace
611	0042	Monocline, anticlinal bend, symbol on trace
611	0043	Monocline, synclinal bend, symbol on trace
611	0044	Plunge of fold, symbol to show general direction

611	0046	AS (Label AS indicating trace of axial surface of fold)
611	0047	CS (Label CS indicating trace of crest line of fold)
611	0048	TS (Label TS indicating trace of trough line of fold)
611	0050	Left arrow
611	0051	Paired left arrows indicating relative lateral fault displacement
611	0052	Right arrow
611	0053	Paired right arrows indicating relative lateral fault displacement
611	0056	Bar and ball
611	0060	Thrust tooth, filled
611	0061	Thrust tooth, open
611	0062	Thrust tooth, open with center line
611	0065	Overturned thrust tooth, filled
611	0066	Overturned thrust tooth, open
611	0067	Overturned thrust tooth, open with center line
611	0070	Detachment fault, tooth filled
611	0071	Detachment fault, tooth open
611	0072	Detachment fault, tooth, open with center line
611	0080	"V" indicating clinkered bed
611	0100	? (Query)
611	0115	U (Label U indicating upthrown)
611	0116	D (Label D indicating downthrown)
611	0117	T (label T indicating movement toward observer, sections only)
611	0118	A (label A indicating movement away from observer, sections only)
611	0120	O (Label O indicating "Older")
611	0122	Y (Label Y indicating "Younger")
611	0124	AM (Label AM indicating aeromagnetic survey)
611	0125	M (Label M indicating ground magnetic survey)
611	0126	G (Label G indicating gravity survey)
611	0128	R (Label R indicating radiometric survey)
611	0130	ML (label ML indicating marine limit)
611	0132	SL (Label SL indicating shoreline")
617	000T	Epicenter of earthquake; requires lookup table number; and other code pairs
620	0100	Adit, tunnel, incline; direction shows direction of entry
620	0101	Inaccessible tunnel, adit, or incline
620	0104	Trench
620	0114	Mine shaft, inclined; location of entry at surface
620	0015	Mine shaft, inclined, abandoned; location of entry at surface
620	0130	Tick indicating crossing survey line (geophysical survey)
630	0010	Breccia pipe
630	0011	Collapse structure, indicating breccia pipe at depth
630	0012	Collapse structure or sink hole
630	0020	Small cone, cinder cone (hornito), vent on lava flow
630	0023	Active volcano (small scale maps)
630	0024	Thermal spring
630	0025	Inactive volcano (small scale maps)
630	0026	Geyser

630	0027	Cinder cone (small scale maps)
630	0028	Fumarole, steam vent
630	0029	Diatreme (small scale maps)
630	0030	Pingo
630	0032	Tick to label downthrown side of normal fault
630	0033	Graben, narrow with label G (small scale maps)
630	0034	Reverse fault, R on upthrown block (small scale maps)
630	0036	Kettle (ice-block depression)
630	0037	Kettles aligned, showing linear trend
630	0040	Dome (small scale maps)
630	0041	Basin (small scale maps)
630	0050	Metamorphic core complex (small scale maps)
630	0055	Salt, shale diapirs (small scale maps)
630	0056	Uplift, local, intensely disturbed (small scale maps)
630	0057	Salt dome (small scale maps)
630	0058	Possible salt dome (small scale maps)
630	0059	Guyot (symbol) small scale maps
630	0060	Seamount; triangles indicate volcanic origin
630	0062	Seamount too small to show outline at map scale (solid fill indicates volcanic origin) (small scale maps)
630	0070	Recent volcano
630	0100	Mine shaft, vertical, or near vertical, surface opening, use adjacent symbols for multiple shafts
630	0101	Mine shaft abandoned, surface opening
630	0102	Prospect pit or small open cut
630	0103	Mine portal or adit
630	0104	Sand, gravel, clay, or placer pit
630	0106	Abandoned sand, gravel, clay, or placer pit
630	0107	Mine portal and open cut
630	0110	Open pit mine, quarry, or glory hole
630	0112	Abandoned open pit mine, quarry, or glory hole
630	0240	Hazardous waste site; second code pair identifies type
640	0003	Crater outline; origin not specified
640	0005	Volcanic crater rim, hachures point toward low point
640	0007	Caldera, margin, outline of topographic wall
640	0010	Lava pond, outline
640	0012	Pressure ridge or tumulus on lava flow, showing crest line
640	0013	Trace of axis of fold marking pressure ridge on lava flow
640	0014	Form lines to show ridges on lava flow normal to local flow direction
650	0016	Lava tube, line shows position of lava tube beneath the surface
640	0017	Fissure, volcanic origin
640	0018	Fissure, lava emitted
640	0019	Flow lobe, line drawn at foot of lobe; hachures point away from lobe
640	0021	Contacts separating different flows derived from the same vent
640	0022	Contacts separating different flows derived from different vents

640	0023	Cracks on surface of lava flow
640	0024	Outline of rootless vent area on lava flow (identified by steeply dipping foliation and lineation
640	0025	Flow lines on lava flow, showing direction of flow
640	0026	Landslide scarp, at top of scarp; ticks point downscarp
640	0028	Landslide toe; ticks point downslope
640	0029	Boundary of sag, sag pond or topographic depression on landslide
640	0030	Path of gully on landslide
640	0031	Meltwater spillway
640	0032	Direction of glacier flow, from geologic evidence
640	0033	Glacially-scoured basin, margin
640	0035	Crest line, moraine
640	0036	Glacial limit (terminus)
640	0037	Minor ridges (crest line) on moraine, till
640	0038	Limit of significant glacial advance
640	0039	Cirque headwall (top of headwall)
640	0040	Glacial (meltwater) channel, abandoned
640	0041	Flow direction of glacial stream
640	0042	Kame terrace scarp
640	0043	Retreat position of stagnant ice
640	0044	Esker, chevrons point in direction of transport
640	0045	Esker, transport direction unknown
640	0046	Fluvial terrace scarp
640	0050	Dune crest
640	0051	Dune crest, hachures point down scarp face
640	0055	Blowout rim, closed depression of eolian origin in dune field
640	0056	Blowout rim, closed depression of eolian origin in bed rock
640	0060	Midoceanic ridge, axis, without rift
640	0061	Midoceanic ridge, axis with rift
640	0062	Oceanic rise, showing margin
640	0063	Surface trace of deep seismo-focal zone
640	0065	Continental slope, margin; solid box used where edge is distinct
640	0068	Transform fault, tick marks indicate downthrown side
640	0069	Outline of basin, triangles point inward
640	0070	Former shoreline of marine limit or former lake
640	0072	Spit or bar, symbol follows axis
640	0074	Shoreline cliff
640	0077	Guyot, outline represents shape
640	0078	Beach ridges
640	0080	Shoreline, aggradational; line follows shoreline, decorations offshore
640	0082	Shoreline, erosional; line follows shoreline, decorations offshore
640	0090	Line of equal thickness (isopach)of defined unit, united indicated by second code pair; elevation indicated by third code pair
640	0092	Line of equal elevation (structure contour) on (first) defined unit; unit indicated by second code pair; elevation indicated by third code pair
640	0094	Line of equal elevation (structure contour) on second defined unit; unit indicated by second code pair; elevation indicated by third code pair

640	0095	Line of equal depth to (first) specified geologic unit; unit indicated by second code pair; elevation of surface indicated by third code pair
640	0096	Line of equal depth to second specified geologic unit; unit indicated by second code pair; elevation of surface indicated by third code pair
640	0097	Lines of equal travel time (geophysical); time value indicated by second code pair
640	0113	Trench (mineral exploration), drawn to scale
640	0140	Fault scarp, showing top edge
640	0142	Fissures or ground cracks formed during earthquake
640	0143	Fissures and sand and(or) other material ejected during earthquake
640	0144	Crater with rim crest, such as sand blowout, formed during earthquake
640	0146	Sunken ground, showing outer limits of subsidence
640	0151	Impact crater, without a raised rim
640	0152	Impact crater, showing raised rim
640	0153	Impact crater, showing outer boundary of wall where different from rim or rim crest
640	0154	Impact crater, showing outer boundary of floor
640	0156	Complex impact crater, showing outer boundary of central mound
640	0180	Deep-sea trench, showing margin; patterned where filled by sedimentation
640	0182	Oceanic rise, showing margin
640	0186	Volcanic ridge, label indicates age or end of volcanism
640	0245	Hazardous waste site boundary, area of site shown to scale
650	010n	Data collection line; location meets map accuracy standard; n is number from lookup table designating line number
651	015n	Data collection line; location may not meet map accuracy standard; n is number from llookup table
650	0900	Leader line, graphic device to connect text labels with labelled feature
660	0001	Contact
660	0010	Fault
660	0012	Shear, mylonite zone
660	0014	Joint trace
660	0028	Trace of tension crack in landslide
660	0030	Trace of slip surface, landslide, Toreva block, block-slump-fault, landslip fault
660	0100	Lineament (from aerial photograph or remotely-sensed data)
660	0124	Fault, located by geophysical method
664	0027	Fault, concealed; location projected to Earth's surface where fault breaks structure contours
669	0001	Contact, planetary map
669	0010	Fault, planetary map
690	0001	Outcrop (area of exposed rock)
690	0010	Area of baked, fused rock formed by burning of coal

690 0012 Area of sheared, broken rock (fault, shear, mylonite zone)
690 0020 Thermal area
690 0031 Periglacial patterned ground
690 0032 Polygonal patterned ground
690 0033 Sorted circles
690 0034 Stone stripes
690 0035 Solifluction lobes
690 0036 Ice wedge polygons
690 0037 Felsenmeer
690 0039 Thermokarst depression
690 0040 Marine abrasion platform
690 0048 Ice contact slope
690 0098 Palimpsest, area around impact feature, morphology of area surrounding crater obscured by ejecta.
690 0100 Artificial fill, earth materials
690 0101 Artificial fill, human-generated refuse (landfill)
690 0102 Tailings, may include tailings pond
690 0104 Mine dump
690 0106 Graded area, extensive amount of mapped geologic unit has been removed
690 0108 Strip mine, area patterned where commodity is striped
690 0114 Open cut or open pit mine, quarry, or glory hole, quarry (top of cut; hachures point toward working)
690 0116 Subsurface workings (mine) projected to surface
690 0200 Area containing identified resources
690 0201 Area of high mineral resource potential
690 0202 Area of moderate mineral resource potential
690 0203 Area of low mineral resource potential
690 0204 Area not evaluated for mineral resource potential, data inadequate
690 0222 Oil field
690 0224 Gas field
690 0226 Oil and gas field

Features, definition requires lookup table

Areas

Feature

699 ____ Minor code provides the number of lookup table
071 ____ Minor code provides number of entry in lookup table

Lines

Feature

687 ____ Clinkered coal bed Minor code provides the number of lookup table
687 ____ Key bed Minor code provides the number of lookup table
687 ____ Vein Minor code provides the number of lookup table

Descriptive

071 ____ Minor code provides number of entry in lookup table

Points

Feature

618 ___ Label Minor code provides number of lookup table

Descriptive

071 ____ Minor code provides number of entry in lookup table

Codes for fold traces are indicated below codes to show accuracy/method of location

For symbols 072 ____ Minor code indicates percentabe of standard size symbol
For text 073 ____ Minor code indicates size, 10 times point size e.g. (60=6 pt.)

For features on non-Earth bodies (planets, moons), a new major code, 699 is assigned to indicate an off-Earth body, and the most appropriate minor code indicates the interpreted feature. 699 thus indicates both the kind of data available and, in most cases, the lack of field check and thus the accuracy of the observation or interpretation. There are too many different observable planets and moons to choose a different major code for each in the 6nn family of numbers; minor codes exist for many of the interpreted off-Earth features, so little must be invented beyond what is already have coded.

The makeup of the digital data will supply the needed information as to whether the data represents an area (identical first and last points), a line (a string of points), or a point (one or two digital points), so that selecting from the area, line, or point listing would not be difficult.

CODE-TO-FEATURE CROSS REFERENCE

PART 2. FEATURE IDENTIFICATION-TO-CODE CROSS REFERENCE

Feature Identification	Code		Feature
Areas			
	690	0001	Outcrop (area of exposed rock)
	690	0010	Area of baked, fused rock formed by burning of coal
	690	0012	Area of sheared, broken rock (fault, shear, mylonite zone)
	690	0020	Thermal area
	690	0031	Periglacial patterned ground
	690	0032	Polygonal patterned ground
	690	0033	Sorted circles
	690	0034	Stone stripes
	690	0035	Solifluction lobes
	690	0036	Ice wedge polygons
	690	0037	Felsenmeer
	690	0039	Thermokarst depression
	690	0040	Marine abrasion platform
	690	0048	Ice contact slope
	690	0098	Palimpsest, area around impact feature, morphology of area surrounding crater obscured by ejecta.
	690	0100	Artificial fill, earth materials
	690	0101	Artificial fill, human-generated refuse (landfill)
	690	0102	Tailings, may include tailings pond
	690	0104	Mine dump
	690	0106	Graded area, extensive amount of mapped geologic unit has been removed
	690	0108	Strip mine, area patterned where commodity is striped
	690	0114	Open cut or open pit mine, quarry, or glory hole, quarry (top of cut; hachures point into working)
	690	0116	Subsurface workings (mine) projected to surface
	690	0200	Area containing identified resources
	690	0201	Area of high mineral resource potential
	690	0202	Area of moderate mineral resource potential
	690	0203	Area of low mineral resource potential
	690	0204	Area not evaluated for mineral resource potential, data inadequate
	690	0222	Oil field
	690	0224	Gas field
	690	0226	Oil and gas field
Lines			
	640	0003	Crater outline; origin not specified
	640	0005	Volcanic crater rim, hachures point toward low point

640	0007	Caldera, margin, outline of topographic wall
640	0010	Lava pond, outline
640	0012	Pressure ridge or tumulus on lava flow, showing crest line
640	0013	Trace of axis of fold marking pressure ridge on lava flow
640	0014	Form lines to show ridges on lava flow normal to local flow direction
650	0016	Lava tube, line shows position of lava tube beneath the surface
640	0017	Fissure, volcanic origin
640	0018	Fissure, lava emitted
640	0019	Flow lobe, line drawn at foot of lobe; hachures point away from lobe
640	0021	Contacts separating different flows derived from the same vent
640	0022	Contacts separating flows derived from different vents
640	0023	Cracks on surface of lava flow
640	0024	Outline of rootless vent area on lava flow (identified by steeply dipping foliation and lineation
640	0025	Flow lines on lava flow, showing direction of flow
640	0026	Landslide scarp, at top of scarp; ticks point downscarp
640	0028	Landslide toe; ticks point downslope
640	0029	Boundary of sag, sag pond or topographic depression on landslide
640	0030	Path of gully on landslide
640	0031	Meltwater spillway
640	0032	Direction of glacier flow, from geologic evidence
640	0033	Glacially-scoured basin, margin
640	0035	Crest line, moraine
640	0036	Glacial limit (terminus)
640	0037	Minor ridges (crest line) on moraine, till
640	0038	Limit of significant glacial advance
640	0039	Cirque headwall (top of headwall)
640	0040	Glacial (meltwater) channel, abandoned
640	0041	Flow direction of glacial stream
640	0042	Kame terrace scarp
640	0043	Retreat position of stagnant ice
640	0044	Esker, chevrons point in direction of transport
640	0045	Esker, transport direction unknown
640	0046	Fluvial terrace scarp
640	0050	Dune crest
640	0051	Dune crest, hachures point down scarp face
640	0055	Blowout rim, closed depression of eolian origin in dune field
640	0056	Blowout rim, closed depression of eolian origin in bed rock
640	0060	Midoceanic ridge, axis, without rift
640	0061	Midoceanic ridge, axis with rift
640	0062	Oceanic rise, showing margin
640	0063	Surface trace of deep seismo-focal zone
640	0065	Continental slope, margin; solid box used where edge is distinct
640	0068	Transform fault, tick marks indicate downthrown side
640	0069	Outline of basin, triangles point inward

640	0070	Former shoreline of marine limit or former lake
640	0072	Spit or bar, symbol follows axis
640	0074	Shoreline cliff
640	0077	Guyot, outline represents shape
640	0078	Beach ridges
640	0080	Shoreline, aggradational; line follows shoreline, decorations offshore
640	0082	Shoreline, erosional; line follows shoreline, decorations offshore
640	0090	Line of equal thickness (isopach)of defined unit, united indicated by second code pair; elevation indicated by third code pair
640	0092	Line of equal elevation (structure contour) on (first) defined unit; unit indicated by second code pair; elevation indicated by third code pair
640	0094	Line of equal elevation (structure contour) on second defined unit; unit indicated by second code pair; elevation indicated by third code pair
640	0095	Line of equal depth to (first) specified geologic unit; unit indicated by second code pair; elevation of surface indicated by third code pair
640	0096	Line of equal depth to second specified geologic unit; unit indicated by second code pair; elevation of surface indicated by third code pair
640	0097	Lines of equal travel time (geophysical); time value indicated by second code pair
640	0113	Trench (mineral exploration), drawn to scale
640	0140	Fault scarp, showing top edge
640	0142	Fissures or ground cracks formed during earthquake
640	0143	Fissures and sand and(or) other material ejected during earthquake
640	0144	Crater with rim crest, such as sand blowout, formed during earthquake
640	0146	Sunken ground, showing outer limits of subsidence
640	0151	Impact crater, without a raised rim
640	0152	Impact crater, showing raised rim
640	0153	Impact crater, showing outer boundary of wall where different from rim or rim crest
640	0154	Impact crater, showing outer boundary of floor
640	0156	Complex impact crater, showing outer boundary of central mound
640	0180	Deep-sea trench, showing margin; patterned where filled by sedimentation
640	0182	Oceanic rise, showing margin
640	0186	Volcanic ridge, label indicates age or end of volcanism
640	0245	Hazardous waste site boundary, area of site shown to scale
650	010n	Data collection line; location meets map accuracy standard; n is number from lookup table designating line number
651	015n	Datacollection line; location may not meet map accuracy standard; n is number from llookup table
650	0900	Leader line, graphic device to connect text labels with labelled feature
660	0001	Contact

660	0010	Fault
660	0012	Shear, mylonite zone
660	0014	Joint trace
660	0028	Trace of tension crack in landslide
660	0030	Trace of slip surface, landslide, Toreva block, block-slump-fault, landslip fault
660	0100	Lineament (from aerial photograph or remotely-sensed data)
660	0124	Fault, located by geophysical method
664	0027	Fault, concealed; location projected to Earth's surface where fault breaks structure contours
669	0001	Contact, planetary map
669	0010	Fault, planetary map

Points, degenerate areas

630	0010	Breccia pipe
630	0011	Collapse structure, indicating breccia pipe at depth
630	0012	Collapse structure or sink hole
630	0020	Small cone, cinder cone (hornito), vent on lava flow
630	0023	Active volcano (small scale maps)
630	0024	Thermal spring
630	0025	Inactive volcano (small scale maps)
630	0026	Geyser
630	0027	Cinder cone (small scale maps)
630	0028	Fumarole, steam vent
630	0029	Diatreme (small scale maps)
630	0030	Pingo
630	0032	Tick to label downthrown side of normal fault
630	0033	Graben, narrow with label G (small scale maps)
630	0034	Reverse fault, R on upthrown block (small scale maps)
630	0036	Kettle (ice-block depression)
630	0037	Kettles aligned, showing linear trend
630	0040	Dome (small scale maps)
630	0041	Basin (small scale maps)
630	0050	Metamorphic core complex (small scale maps)
630	0055	Salt, shale diapirs (small scale maps)
630	0056	Uplift, local, intensely disturbed (small scale maps)
630	0057	Salt dome (small scale maps)
630	0058	Possible salt dome (small scale maps)
630	0059	Guyot (symbol) small scale maps
630	0060	Seamount; triangles indicate volcanic origin

630	0062	Seamount too small to show outline at map scale (solid fill indicates volcanic origin) (small scale maps)
630	0070	Recent volcano
630	0100	Mine shaft, vertical, or near vertical, surface opening, use adjacent symbols for multiple shafts
630	0101	Mine shaft abandoned, surface opening
630	0102	Prospect pit or small open cut
630	0103	Mine portal or adit
630	0104	Sand, gravel, clay, or placer pit
630	0106	Abandoned sand, gravel, clay, or placer pit
630	0107	Mine portal and open cut
630	0110	Open pit mine, quarry, or glory hole
630	0112	Abandoned open pit mine, quarry, or glory hole
630	0240	Hazardous waste site; second code pair identifies type

Points, degenerate lines

620	0100	Adit, tunnel, incline; direction shows direction of entry
620	0101	Inaccessible tunnel, adit, or incline
620	0104	Trench
620	0114	Mine shaft, inclined; location of entry at surface
620	0015	Mine shaft, inclined, abandoned; location of entry at surface
620	0130	Tick indicating crossing survey line (geophysical survey)

Points projected to the surface of the Earth

617	000T	Epicenter of earthquake; requires lookup table number; and other code pairs

Points

600	0001	Measurement of bedding, sedimentary rocks
600	0002	Measurement of bedding, contorted sedimentary rocks
600	0003	Measurement of bedding, approximate, sedimentary rocks
600	0004	Measurement of bedding, stratigraphic top direction known from local features, sedimentary rocks
600	0005	Measurement of bedding, overturned beds
600	0006	Measurement of bedding, overturned beds, stratigraphic top direction known from local features
600	0007	Measurement of bedding, beds overturned more than 180 degrees

600	0009	Minor fault, showing strike and dip
600	0010	Measurement of bedding from aerial photograph
600	0011	Foliation, layered gneiss
600	0012	Foliation, contorted layered gneiss
600	0014	Foliation, bedding, layered gneiss top known from local features
600	0016	Foliation, inclined parallel to overturned bed in layered gneiss; top known from local features
600	0018	Massive igneous rock
600	0020	Attitude of foliation and layering in igneous rock
600	0022	Flow foliation, approximate, contorted, igneous rock
600	0023	Cumulate foliation in igneous rock; vertical; top is known from local features
600	0024	Cumulate foliation, layering, igneous rock
600	0025	Cumulate foliation, layering, contorted, igneous rock
600	0026	Cumulate foliation, igneous rock, top known from local features
600	0027	Cumulate foliation parallel to overturned layering in igneous rock; top known from local features
600	0028	Compaction foliation, ashflow tuff
600	0029	Compaction foliation, approximate, contorted ashflow tuff
600	0030	Measurement of strike and dip on rock cleavage
600	0031	Measurement of strike and dip on vein
600	0032	Measurement of strike and dip on joint surface
600	0033	Axial surface minor fold, horizontal
600	0034	Axial surface minor antiform, inclined
600	0035	Axial surface minor anticline, inclined
600	0036	Axial surface minor overturned anticline,inclined
600	0037	Axial surface minor synform, inclined
600	0038	Axial surface minor syncline, inclined
600	0039	Axial surface minor overturned syncline, inclined
600	0040	Minor fold axis
600	0041	Axis, minor anticline
600	0042	Axis, minor syncline
600	0043	Axis, dextral minor fold
600	0044	Axis, sinistral minor fold
600	0045	Axes, minor folds. showing bearing and plunge
600	0050	Lineation, bearing and plunge, type undesignated
600	0051	Mineral lineation, bearing and plunge, (B lineation) on foliation surface
600	0052	Mineral lineation (A lineation), bearing and plunge, on foliation surface
600	0053	Lineation, slip feature [groove, striae, (A lineation)]x on foliation surface
600	0055	Linear flow feature, bearing and plunge, on flow foliation surface
600	0056	Minor fold axis defined by flow foliation
600	0057	Flow direction from pipe amygdules
600	0058	Mineral lineation, cumulate rocks, showing bearing and plunge
600	0059	Trough banding, cumulate rocks, showing bearing and plunge
600	0060	Lineation on compaction surface, ashflow tuff
600	0061	Lineation, minor folds normal to flow in ashflow tuff

600	0062	Lineation, intersection of bedding and cleavage, showing bearing and plunge
600	0063	Lineation, intersection of foliation and cleavage, showing bearing and plunge
600	0064	Lineation on cleavage surface, showing bearing and plunge
600	0065	Lineation, slip on fault surface, showing bearing and plunge
600	0066	Flow direction and plunge, basal surge, ash deposits (determined from bed forms of antidunes)
600	0067	Lineation, penetrative; used in combination with foliation symbol; lineation not in foliation surface; showing bearing and plunge
600	0068	Boudinage, showing bearing and plunge
600	0070	Arrow, showing direction and plunge; requires codes for direction of rotation of arrow and angle of plunge
600	0071	Ice molded land form (drumlin, drumlinoid form)
600	0072	Glacial striae, direction of glacial flow
600	0074	Glacial striae, direction of flow unknown
600	0075	Fluvial transport direction
600	0076	Fluvial transport direction from imbrication
600	0077	Fluvial transport direction from cross beds
600	0078	Fluvial transport direction from flute casts
600	0080	Sediment transport direction, determined from dune morphology
600	0081	Sediment transport direction, determined from cross bedding in vertical or near-vertical section
600	0082	Sediment transport direction, determined from dune bedding in horizontal or near-horizontal section
600	0100	Tick mark to indicate dip and strike of surface (e.g. contact, fault
600	0102	Arrow to indicate direction and plunge of measured linear feature on surface (e.g. contact, fault)
600	0104	Triangle symbol to indicate locality of observation
600	0139	Tick to indicate direction of dip crossover (Place where surface changes dip from one side to the other)
600	0151	Impact crater, symbol used for crater too small to outline at map scale
600	0152	Impact crater, primary
600	0153	Impact crater, secondary, formed by debris thrown up from primary crater
600	0200	Diamond drill hole
600	0220	Dry hole, hydrocarbon exploration
600	0222	Oil well
600	0224	Gas well
600	0226	Oil and Gas well
607	000T	Fossil locality; requires lookup table for locality and accession number
611	0020	Label A active or recently active earthflow, landslide
611	0022	Label D dormant earthflow, landslide
611	0024	Label DF Debris flow
611	0026	Label EF Earth flow

611	0030	Antiform, symbol on trace
611	0031	Anticline, symbol on trace
611	0032	Asymmetric anticline, symbol on trace
611	0033	Overturned anticline, symbol on trace
611	0034	Inverted anticline, symbol on trace
611	0035	Fold having vertical or near-vertical axis
611	0036	Synform, symbol on trace
611	0037	Syncline, symbol on trace
611	0038	Asymmetric syncline, symbol on trace
611	0039	Inverted syncline, symbol on trace
611	0040	Arrow to show direction of flow as label on flow lines
611	0041	Monocline (single trace). symbol on trace
611	0042	Monocline, anticlinal bend, symbol on trace
611	0043	Monocline, synclinal bend, symbol on trace
611	0044	Plunge of fold, symbol to show general direction
611	0046	AS (Label AS indicating trace of axial surface of fold)
611	0047	CS (Label CS indicating trace of crest line of fold)
611	0048	TS (Label TS indicating trace of trough line of fold)
611	0050	Left arrow
611	0051	Paired left arrows indicating relative lateral fault displacement
611	0052	Right arrow
611	0053	Paired right arrows indicating relative lateral fault displacement
611	0056	Bar and ball
611	0060	Thrust tooth, filled
611	0061	Thrust tooth, open
611	0062	Thrust tooth, open with center line
611	0065	Overturned thrust tooth, filled
611	0066	Overturned thrust tooth, open
611	0067	Overturned thrust tooth, open with center line
611	0070	Detachment fault, tooth filled
611	0071	Detachment fault, tooth open
611	0072	Detachment fault, tooth, open with center line
611	0080	"V" indicating clinkered bed
611	0100	? (Query)
611	0115	U (Label U indicating upthrown)
611	0116	D (Label D indicating downthrown)
611	0117	T (label T indicating movement toward observer, sections only)
611	0118	A (label A indicating movement away from observer, sections only)
611	0120	O (Label O indicating "Older")
611	0122	Y (Label Y indicating "Younger")
611	0124	AM (Label AM indicating aeromagnetic survey)
611	0125	M (Label M indicating ground magnetic survey)
611	0126	G (Label G indicating gravity survey)
611	0128	R (Label R indicating radiometric survey)

611	0130	ML (label ML indicating marine limit)
611	0132	SL (Label SL indicating shoreline")

Descriptive

060	0001	Approximately located
060	0002	Inferred
060	0003	Concealed
060	0004	Gradational
060	0010	Fault
060	0011	Sub-vertical fault
060	0012	Normal fault
060	0014	Reverse fault
060	0016	Strike slip fault
060	0017	Right lateral strike slip fault
060	0018	Left lateral strike slip fault
060	0019	Oblique slip fault
060	0020	Thrust fault
060	0024	Overturned thrust fault
060	0026	Detachment fault
060	0030	Fold, beds upright
060	0031	Overturned fold (beds on one limb overturned)
060	0032	Inverted fold (beds on both limbs overturned)
060	0040	Lineation, elongate minerals
060	0041	Lineation, streaked mineral aggregates
060	0045	Lineation, "B" lineation, parallel to minor fold axes
060	0046	Lineation, "A" lineation, parallel to slip direction
060	0048	Lineation, intersection of surfaces
060	0124	Location from aeromagnetic survey
060	0125	Location from ground magnetic survey
060	0126	Location from gravity survey
060	0128	Location from radiometric survey
060	0200	Dry hole, radial ticks at 0°, 90°, 180°, and 270°, use with 600 0220
060	0202	Abandoned well, diagonal line across well symbol
060	0204	Capped well, T symbol at top of well symbol
060	0205	Shut-in well, horizontal line through well symbol
060	0207	Show of oil
060	0208	Show of gas
060	0209	Show of oil and gas
060	0210	Well converted to water well, diagonal arrow across well pointing outward
060	0212	Injection well, inward-directed arrow
060	0213	Water injection well, point in center of well symbol
060	0214	Water input well, X symbol inside well symbol
060	0215	Salt water disposal, triangle symbol with ticks around well symbol

060	0351	Hazardous waste, direction of surface leachate flow from site
060	0352	Hazardous waste site, active, symbol fill
060	0353	Hazardous waste site, closed, vertical bar through symbol
060	0354	Hazardous waste site, cleanup in progress, half-fill of symbol
060	0355	Hazardous waste site, cleanup complete
061	0129	Horizontal bedding measured from aerial photograph, symbol
061	0130	Gently inclined bedding, measured from aerial photograph, symbol
061	0131	Moderately inclined bedding, measured from aerial photograph, symbol
061	0132	Steeply inclined bedding, measured from aerial photograph, symbol
061	0133	Vertical or near-vertical bedding measured from aerial photography, symbol

Parameter, minor code provides value

063	0xxx	Angle of rotation, clockwise (nearest whole degree
064	00yy	Angle of dip or plunge (nearest whole degree)
065	mmmm	Measurement in meters (value from minor code)
065	ffff	Measurement in feet (value from minor code)
067	0nnn	Feature of numbered type (value from minor code)
068	0001	Feature measured at point of coincidence with other features (digital symbol's index point is at end of strike line where symbol's strike lines intersect
070	0001	Graded bedding symbol, short dashes to go beneath strike line
070	0002	Graded bedding symbol, short dashes beneath strike line interrupted around overturned dip symbol
070	0003	Cross bedding symbol, arcs go beneath strike line
070	0004	Cross bedding symbol, arcs beneath strike line interrupted around overturned dip symbol
071	000T	Entity of entry in lookup code, T is number assigned to entity
072	0___	For symbols, minor code indicates percent of standard size symbol
073	____	Minor code indicates size, 10 times point size (such as 60=6 points)

Features, definition requires lookup table

Areas

Feature

699	____	Minor code provides the number of lookup table
071	____	Minor code provides number of entry in lookup table

Lines

Feature

687 ____ Clinkered coal bed Minor code provides the number of lookup table
687 ____ Key bed Minor code provides the number of lookup table
687 ____ Vein Minor code provides the number of lookup table

Descriptive

071 ____ Minor code provides number of entry in lookup table

Points

Feature

618 ___ Label Minor code provides number of lookup table

Descriptive

071 ___ Minor code provides number of entry in lookup table

Codes for fold traces are indicated below codes to show accuracy/method of location

For symbols 072 ____ Minor code indicates percentabe of standard size symbol
For text 073 ____ Minor code indicates size, 10 times point size (e.g., 60=6 pt.)

2.1 GEOLOGIC MAP SYMBOLS

2.1.0 INTRODUCTION

The design and description of map symbols, including line widths and styles and sizes of typefaces given in this standard, are intended for use in the compilation and production of geologic maps at scales ranging from 1:24,000 to 1:100,000. Most of the symbols can be reduced in size for use on smaller scale maps, as explained below.

Specifications in this standard are given for final publication size. For the sake of simplicity, maps should be compiled at publication size. Compliance with this standard requires that compilation, digitizing, and (or) drafting of maps, including all symbols and line widths, at other than publication size be geometrically scaled so that the symbols and line weights in the published maps closely resemble the size of symbols and line widths in this standard. Compilations at sizes smaller than publication size should be avoided because they require enlargement, which emphasizes any imperfections that may be present and thereby decreases publication quality. Care must be taken in working with geologic maps assembled by using digital techniques. A small-scale geologic map enlarged digitally will not likely meet map accuracy standards for a larger scale; the spatially related data on the enlarged map can not be used for analyses that require a higher level of accuracy than the geologic data on the original small-scale map. Similarly, geologic map data reduced from large-scale to small-scale maps may lose positional accuracy and proper relations to the base map. Such reduced data must be used with care.

Maps to be published at scales smaller than 1:100,000 require that most symbols be geometrically scaled at least 20 percent smaller than the symbols shown in this standard. Owing to limitations on down scaling posed by legibility, some symbols on small-scale maps may remain larger than the proportions of the geologic features might indicate. Where symbols become too crowded on small-scale maps, the compiler should select those that are most pertinent to the purpose of the map.

In addition to being geometrically and mathematically correct, symbols used on geologic maps should be:

1. Accurately located with respect to the point of field observation and measurement,
2. Accurately explained in the map explanation, and
3. In agreement with accepted practice and scientific principles; that is, symbols selected must be appropriate to show the kind of feature and its characteristics and must be in compliance with this standard.

Symbols having similar basic characteristics but with some differences in their detail are grouped into "families," which are further divided into sets in much the same say that family, genus, and species are classified in biological nomenclature. Family-level symbols used on geologic maps show the following geologic concepts:

1. Traces of surfaces
2. Planar elements
3. Linear elements
4. Morphometric and morphogenetic features
5. Features related to natural resources, land use, and other applications of geologic data

Relative or gradational values of measured physical parameters may be shown as part of a symbol, as for example, the dip of beds in the strike-and-dip symbol. Family-level symbols are restricted in usage so that uniformity of meaning is maintained.

2.1.0.1 POSITIONING OF MAP SYMBOLS

The 1.00 mm accuracy standard recognized in Section 1.0 of this document applies in the field to accuracy of location and geologic control. The accuracy of primary location must be maintained carefully through all steps leading to publication in order to maintain this degree of precision as a graphical and digital standard. Table 2.1.0.1 provides comparison of the Federal map standards with line widths for maps at various scales.

Table 2.1.0.1. Accuracy standard for location of map symbols relative to the 1:24,000 standard

Scale	Accuracy (meters)	Accuracy (feet)	Equivalent line width (meters)	Equivalent line width (feet)
1:2,400	1.2	4	5	0.20
1:24,000	12	40	0.5	0.02
1:48,000	24	80	0.25	0.01
1:100,000	50	164	0.12	0.005
1:125,000	63	206	0.1	0.004
1:250,000	125	410	0.05	0.002

The center of gravity of nonstandard free-form (asymmetrical, usually nonspherical or nonrectangular) symbols is the visual focal point or area of greatest concentration, significance, or interest; this center marks the observation point unless otherwise specified in the standard.

Symbols showing minor features are designed so that they may be combined into unambiguous composite symbols. Free-form and linear symbols should be designated to portray direction and angular value accurately if combined. Symbols should clearly connote the salient geometric properties of the structural observations that are being portrayed.

The following symbols comprise the standard for representation of geologic data on maps. Reference numbers preceding each symbol in the following standard facilitate reference to and use of the symbol.

[2.1 GEOLOGIC MAP SYMBOLS follows]

2.1 GEOLOGIC MAP SYMBOLS

2.1 CONTACTS, BOUNDARIES LOCATED BY GEOPHYSICAL METHODS, AND KEY BEDS

CONTACTS

The accuracy of location of linear traces is indicated graphically by the pattern of the line on the map.

The preferred phrasing used to describe contacts and traces of beds is:

Contact—Dashed where approximately located, short dashed where inferred, dotted where concealed, queried where uncertain

Gradational contact

Contact—Located by geophysical method (add explanation of method used and accuracy as applied)

A tick drawn in the direction of true dip may be added to contacts or traces of beds drawn as solid lines or long dashes. If the tick mark is shown with a dip angle, the symbol represents an observation on the contact or bed.

Annotations to intrusive contacts may indicate the relative age of units separated by a contact.

Annotations to traces of beds may indicate the thickness of the bed or other parameter measured at a designated locality.

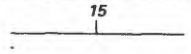
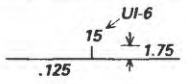
The standard line thickness for contacts on published colored maps is 0.125 mm [0.005 in.]. On black and white maps of great complexity, a line width of 0.15 mm is recommended, except for a contact located by geophysical methods, which generally has a width of 0.30 mm. If the geologic pattern is not too complex, a line width of 0.20 mm is recommended.

Code for contact:

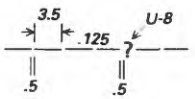
660 0001 Contact

Codes to show accuracy and method of location:

060 0001 Approximately located
060 0002 Inferred
060 0003 Concealed
060 0004 Gradational
060 0124 Aeromagnetic survey
060 0125 Ground magnetic survey
060 0126 Gravity survey
060 0128 Radiometric survey

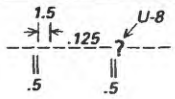
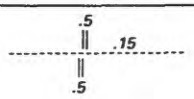
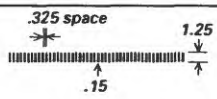
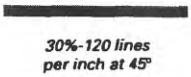
Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.1.1		**Contact— Showing dip**	Location meets map accuracy standard		Solid line **660 0001** contact Tick 600 0100 Rotation 063 0xxx Dip 064 00yy

A contact drawn as a solid line meets the 1.00 mm (0.04 in.) location accuracy standard. Do not use queries on solid lines to indicate uncertainty of location; if a contact is approximately located, draw as a dashed line. Draw the ticks showing dip in the direction of true dip; these generally will not be normal to the contact trace

2.1.2		**Contact— Approximately located, queried where uncertain**	Location may not meet map accuracy standard		Contact **660 0001** Approximate 060 0001 Query 611 0100 Rotation 063 0xxx

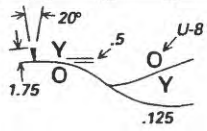
Contact, approximately located, may not meet 1.00 mm location accuracy standard. Add queries as needed to indicate local uncertainty in a part of a contact. The location of queries is to be determined by the compiler.

Use of a "scratch boundary" on a map (adjacent differently colored or patterned areas that have no separating line between the two contrasting areas) generally has not been explained on geologic maps. Use of this graphic convention implies uncertainty of location, not of the existence of the boundary. Its use other than for an approximately located boundary, such as an approximate contact, should be defined in the map explanation. Use this graphic device sparingly.

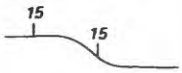
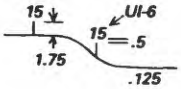
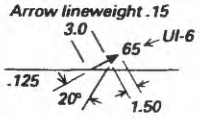
Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.1.3	--------?---	**Contact—Inferred, queried where uncertain**	Existence of the contact, as well as its location, must be inferred from indirect evidence		Contact **660 0001** Inferred 060 0002 Query 611 0100 Rotation 063 0xxx
2.1.4	----------	**Contact—Concealed**	Dotted line represents trace of contact beneath a covering unit or water		Contact **660 0001** Concealed 060 0003
2.1.5		**Contact—Gradational**	Indicates gradual change in lithology across contact, position arbitrary at map scale		Contact **660 0001** Gradational 060 0004
2.1.6			Line symbol (above) preferred		

Concealed (dotted) contacts are drawn beneath a mapped geologic unit or water. The dotted line represents the trace of a contact that is buried beneath a cover unit and is projected to the Earth's surface. The location is approximate unless otherwise noted.

Draw line segments perpendicular to trace of boundary centered on the trace (best estimated position between mapped units) to indicate gradual change of lithology or intertonguing of units that cannot be shown at map scale. Use sparingly. Show in black.

2.1.7		**Point of triangle shows locality where feature can be seen, here a contact between igneous rocks**	Labels indicate observed feature		Triangle **600 0104** Rotation 063 0xxx
2.1.8 2.1.9		**Label O indicates older unit** **Label Y indicates younger unit**	O and Y used to label locality between igneous units where relative ages can be determined		O 611 0120 Y 611 0122

Triangle designates a place where the contact can be seen; O and Y are used to identify relative ages determined for intrusive or extrusive rock units at the designated locality.

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.1.10		**Contact—Tick indicates dip of contact**	If the tick is not shown with the angle of dip, tick indicates general direction of dip A given angle of dip indicates measurement of true dip direction and magnitude		Contact **600 0100** Rotation 063 0xxx 600 0100 Rotation 063 0xxx Dip 064 00yy
2.1.11		**Contact—arrow shows direction and plunge of linear feature on contact surface**			Symbol 600 0102 Rotation 063 0xxx Plunge 064 00yy

Tick shows direction of true dip of a contact or other surface. Use the same line weight for the tick as for the contact. If the tick mark is not shown with a number, tick indicates general dip direction. If the tick mark is shown with the dip angle, symbol indicates a measurement of the dip of the surface at the locality indicated by the tick. The arrow symbol is used for lineation on the contact surface.

BOUNDARIES LOCATED BY GEOPHYSICAL METHODS

Geophysical methods generally define boundaries between rock bodies by measured contrasts in rock properties. If such boundaries are concealed, the survey may not identify definitively whether the boundary is a contact or a fault. In cases where the boundary is identified as a contact from other supporting evidence, or where the geologic character of the boundary is uncertain but is likely a contact, the patterned lines and labels provided below are used to represent the boundary on a map. If a boundary is identified definitively as a fault by the geophysical survey or from other evidence that contributes to the survey, use line symbols for faults defined by geophysical surveys (symbols 2.2.7 to 2.2.10).

Location of a survey line is shown by a cross tick. The map explanation should describe briefly the method of survey and should specify the uncertainty of location inherent in the method. Data points for a gravity survey and data values should be shown by symbols and values. Use the line pattern shown below for ground magnetic survey when drawing contacts located by the use of gravity and radiometric surveys.

Explanation and coding tables must specify type of survey. Use survey station symbol to indicate control points for survey.

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.1.12		**Boundary—Located by geophysical methods**	Technique and accuracy should be described in map explanation	3.5; .125; .5	Contact **660 0001** Contact from aeromagnetic survey 060 0124 Contact from ground magnetic survey 060 0125 Contact from gravity survey 060 0126 Contact from radiometric survey 060 0128
2.1.12	AM		Label AM indicates aeromagnetic survey	.5; AM; U-8; .125; .5	AM 611 0124
2.1.13	M		Label M indicates ground magnetic survey		M 611 0125
2.1.14	G		Label G indicates gravity survey		G 611 0126
2.1.15	R		Label R indicates radiometric survey		R 611 0128
2.1.16	AM	**Ticks indicate survey lines**	Orientation of cross ticks follows survey line	1.25; AM; .125	Cross tick 620 0130 Rotation 063 0xxx
2.1.17		**Data collection line—Accurately located**	Location meets map accuracy standard	.1; Dash 3.75 to 6.25; Space 3.75 to 25.0	650 000n
2.1.18		**Data collection line—Aerial survey**	Location may not meet map accuracy standard	.1; Dash 7.5 to 15.0; Space 7.5 to 50.0	651 000n
2.1.19	△	**Survey station**		Dot diameter .3; .15; 1.75; 60°	**600 0105**

KEY BEDS

The trace of a key bed is shown by a line, letters designating name of the bed, and a number specifying its thickness in meters as measured at the locality that is shown by the triangle. Symbol shows trace of a bed that is too narrow to show as an area at the map scale. The units and letters used as labels are taken from a lookup table.

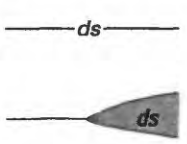
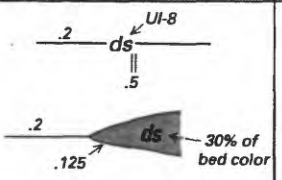
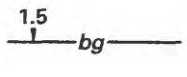
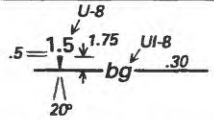
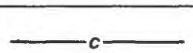
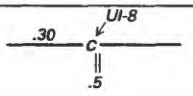
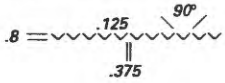
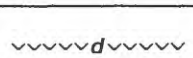
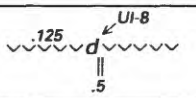
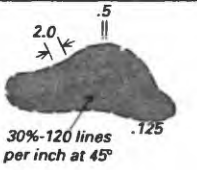
Codes are as follows:

Trace: 689 000T 071, 000N. T is the number of the lookup table; N is the number of the entry designating the rock unit in the table.

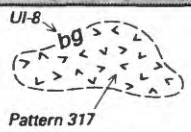
Label: 618 000T 071 000N. T is the number of the lookup table; N is the number of the entry in the table for the plotted label.

Line width 0.30 mm; if approximately located, dash length 3.80 mm, space length 0.50 mm; if concealed, dash length 0.50 mm, space length 0.50 mm.

One example shows a coal bed. Letters indicate name of bed; *c* may be used to indicate a coal bed. On color maps, show in black, cyan, green, or red. Thickness in meters. Traces of beds are used normally for economically important beds or stratigraphic markers.

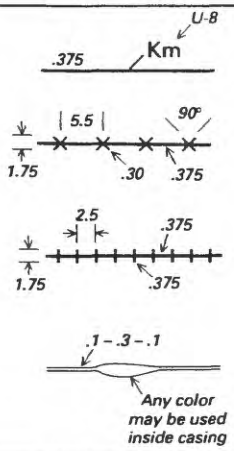
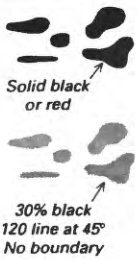
Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.1.20		**Trace of key bed or dike— Dashed where approximately located, dotted where concealed**	Labels within trace designate key bed Where mapped as an area, use a color within contacts that is 30 percent of bed color (area boundary is same color as key bed)		Key bed **689 000T** 071 000N Approximate 060 0001 Concealed 060 0003
2.1.21		**Point of triangle indicates place where bed was measured in meters**	Number shows thickness of (coal) bed in meters		Symbol 600 0104 Rotation 063 0xxx Numbers 066 00mm
2.1.22		**Label c indicates coal bed**	Labels are used to refer to individually mapped units		Labels 618 000T for bed 071 000N
2.1.23		**Clinkered coal bed— V's point downward stratigraphically**	Trace of coal bed that has been baked and fused Symbol not shown where bed is concealed		Bed **687 000T** 071 000N "V" symbol 611 0070 Rotation 063 0xxx
2.1.24		**Label *d* indicates name of coal bed**			Label 618 000T 071 000N
2.1.25		**Clinkered coal bed**	Mapped area of baked and fused rock that has been formed by burning of coal beds. If bedrock color is to be shown, use a red or black v pattern		Clinkered coal bed **699 000T** Unit name 071 000N Clinkered bed 690 0010

The trace of a clinkered coal bed is shown as a line of v's. Each v points downward stratigraphically, and the tops of the v's follow the trace. Show in the same color that is used for areas of baked and fused rock.

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.1.26		**Label *bg* indicates name of burned bed**	Labels are used to refer to individual coal beds		Label 618 000T for bed 071 000N

Trace: 689 000T 071 000N. Rock unit; T is the number of the lookup table; N is the number of the entry designating the unit in the table.

Label: 618 000T 071 000N. T is the number of the lookup table; N is the number of the entry in the table for the plotted label.

2.1.27		**Clay bed**	Labels and numbers used as above for key bed		Key bed 689 000T 071 000N
2.1.28		**Dike—Label indicates rock type**	Dikes normally are shown in color; decorating symbols also may be used to distinguish different rock types		Key bed 689 000T 071 000N
2.1.29		**Outcrops of a key bed**	Outcrops of bedrock (an overprint pattern on a mapped rock unit)		690 0001 Approximate 060 0001

Show outcrop area in solid red if author wishes to accentuate small areas or by using a 30 percent black overprint. Show area of many small, closely spaced outcrops by using a 30 percent black overprint. Solid line boundary indicates well-located boundary of outcrop. Scratch boundary indicates outcrop limits are located approximately; symbol normally used in areas of scanty outcrop. The overprint of parallel horizontal lines that was used on some older maps is not recommended. It imparts a directional component to the graphical presentation, which is not appropriate to most maps.

2.2 FAULTS

The accuracy of the location of faults is shown graphically by the pattern of the line, in the same manner as for contacts. The relative offset is shown by symbol or ornamentation.

The preferred phrasing used to describe faults is:

Fault—Dashed were approximately located, short dashed where inferred, dotted where concealed, queried where uncertain

Thrust fault (or overturned thrust normal, reverse, detachment, strike-slip, oblique-slip fault)

Fault—Located by geophysical methods (add explanation as described below for faults located by geophysical methods (symbols 2.2.7 to 2.2.10))

A tick drawn in the direction of true dip may be added to faults that are shown as solid lines or long dashes. If the tick is given with a dip angle, the symbol represents an observation on the fault at the place indicated. Symbols can be used to indicate relative movement or measurements made of linear features, such as slickensides on fault surfaces. Symbols and annotations near faults may indicate relative age of movement or magnitude of offset.

The inferred fault symbol is used on a part of a fault where the existence of a fault cannot be determined directly by observation or by interpolation between observations. The location of queries is to be determined by the compiler. Concealed (dotted) faults are drawn beneath a mapped geologic unit or water. The dotted line represents the trace of a buried fault that is projected to the Earth's surface; the location is approximate unless otherwise noted.

Text aligned parallel to the trend of a fault is used to show its name. On a map, the fault name in 8 point (pt) type follows a fault trace on the north or west side of the fault; especially important faults may be named by using type sizes as large as 12 pt.

The standard line thickness for fault traces is 0.375 mm. A line thickness of 0.30 mm may be substituted as needed on complex maps. Although applied rarely in the past, different line thicknesses should not be used to indicate amounts of offset on faults. If offset is known at a locality, use a triangle to designate the locality and to label the offset in meters.

Codes for faults
660 0010

Codes for different types of faults:

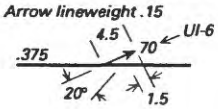
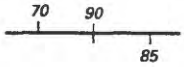
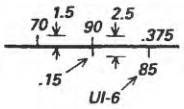
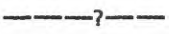
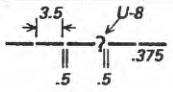
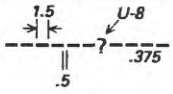
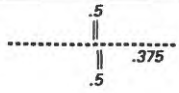
060 0010	Fault
060 0011	Subvertical fault
060 0012	Normal fault
060 0014	Reverse fault
060 0016	Strike-slip fault
060 0017	Right-lateral strike-slip fault
060 0018	Left-lateral strike-slip fault
060 0019	Oblique strike-slip fault
060 0020	Thrust fault
060 0024	Overturned thrust fault
060 0026	Detachment fault

Codes to show accuracy and method of location:

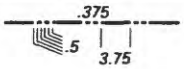
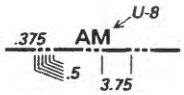
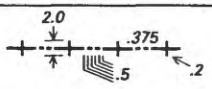
060 0001	Approximately located
060 0002	Inferred
060 0003	Concealed
060 0124	Aeromagnetic survey
060 0125	Ground magnetic survey
060 0126	Gravity survey
060 0128	Radiometric survey

FAULTS

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.2.1	GOLDEN FAULT	**Fault—Showing name**	Solid line indicates 1.00 mm location accuracy standard has been met Fault name aligned to follow trace on north or west side	UI-8 ↙ .5 = GOLDEN FAULT .375	Fault **660 0010** Name 618 000T 071 000N

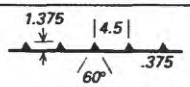
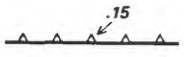
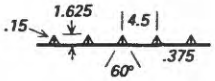
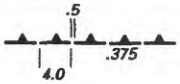
Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.2.2		**Fault—Arrow shows direction and plunge of linear feature, such as a slickenside, on a fault surface**	Letters may be used to indicate type of lineation		Linear feature **600 0102** Rotation 063 0xxx Plunge 064 00yy Letters 618 000T 071 000N
2.2.3		**Fault—Tick shows location of dip crossover (vertical dip) of high-angle fault**	Ticks showing direction of dip should be given on both sides of crossover tick, or label 90 to indicate observed vertical dip		Crossover tick **600 0139** Rotation 063 0xxx 064 0090 Tick 600 0100 Rotation 063 0xxx Dip 064 00yy
2.2.4		**Fault—Approximately located, queried where uncertain**	Fault exists, but location may not meet accuracy standard		Fault **660 0010** Approximate 060 0001
2.2.5		**Fault—Inferred, queried where uncertain**	Existence of the fault, as well as its location, must be inferred from indirect evidence		Fault **660 0010** Inferred 060 0002
2.2.6		**Fault—Concealed**	Dotted line represents projected trace of fault beneath a covering unit or water		Fault **660 0010** Concealed 060 0003

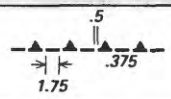
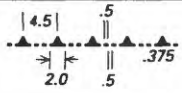
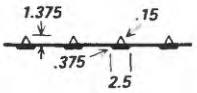
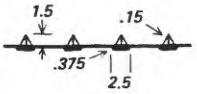
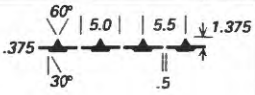
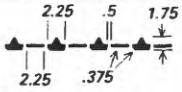
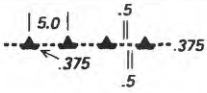
FAULTS LOCATED BY GEOPHYSICAL METHODS

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.2.7		**Fault—Located by geophysical methods**	Technique and accuracy should be described in map explanation		Fault **660 0124** Location from aeromagnetic survey 060 0125 Location from ground magnetic survey 060 0125 Location from gravity survey 060 0126 Location from radiometric survey 060 0128
2.2.7	AM		Label AM indicates aeromagnetic survey		AM 611 0124
2.2.8	M		Label M indicates ground magnetic survey		M 611 0125
2.2.9	G		Label G indicates gravity survey		G 611 0126
2.2.10	R		Label R indicates radiometric survey		R 611 0128
2.2.11		**Ticks indicate survey lines**	Orientation of cross ticks follows survey line		Cross tick 651 000x Rotation 063 0xxx

THRUST FAULTS

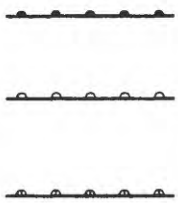
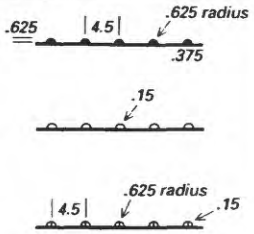
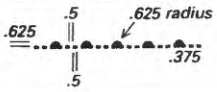
If more than one type of thrust is used, describe types and generations in explanation of map. The size of the teeth and their spacing may be reduced to 60 percent of standard size in order to accommodate crowding on a particular map, but all teeth should be the same size on a given map. Do not use tooth size or spacing to designate different faults or types of faults.

2.2.12		**Thrust fault — Sawteeth on upper plate**	Sawteeth are used to emphasize thrust faults and to indicate upper plate (not direction of thrusting)		Fault **660 0010** Thrust 060 0020 Filled tooth symbol 611 0060 Rotation 063 0xxx
2.2.13		**Second generation**	Different colors may be used to show different thrusts		Second type, add code 067 0002 Open tooth 611 0061 Rotation 063 0xxx
2.2.14		**Third generation**			Third type, add code 067 0003 Tooth with center line 611 0062 Rotation 063 0xxx
2.2.15		**Thrust fault— Approximately located**			Fault **660 0010** Thrust 060 0020 Approximate 060 0001

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.2.16		**Thrust fault—Inferred**			Fault **660 0010** Thrust 060 0020 Inferred 060 0002
2.2.17		**Thrust fault—Concealed**			Fault **660 0010** Thrust 060 0020 Concealed 060 0003
2.2.18		**Overturned thrust fault—Base of sawteeth on upper plate**			Fault **660 0010** Overturned thrust 060 0024 Overturned thrust tooth 611 0065
2.2.19		**Second generation**			Second type, add code 067 0002 Overturned thrust tooth 611 0066
2.2.20		**Third generation**			Third type, add code 067 0003 Overturned thrust tooth 611 0067
2.2.21		**Overturned thrust fault—Approximately located**			Fault **660 0010** Overturned thrust 060 0024 Overturned thrust tooth 611 0065 Approximate 060 0001
2.2.22		**Overturned thrust fault—Inferred**			Fault **660 0010** Overturned thrust 060 0024 Overturned thrust tooth 611 0065 Inferred 060 0002
2.2.23		**Overturned thrust fault—Concealed**			Fault **660 0010** Overturned thrust 060 0024 Overturned thrust tooth 611 0065 Concealed 060 0003

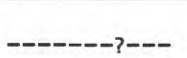
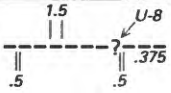
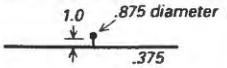
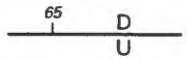
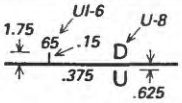
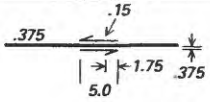
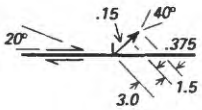
DETACHMENT FAULTS

Half-circle symbols are plotted on upper plate above detachment surface. Different colors may be used to distinguish sets of detachment faults on color maps. Do not use different sizes of teeth or different spacings to show different types of faults.

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.2.24		**Detachment fault—Teeth on upper plate**	Teeth (half-circles) are used to indicate upper plate Open teeth may be used to indicate a second generation or type of fault Different colors of teeth may be used for similar purposes		Fault **660 0010** Detachment 060 0026 Filled tooth 611 0070 Second type 067 0002 Open tooth 611 0071 Third type 067 0003 Third tooth 611 0072
2.2.25		**Detachment fault—Approximately located**			Fault **660 0010** Detachment 060 0026 Approximate 060 0001
2.2.26		**Detachment fault—Inferred**			Fault **660 0010** Detachment 060 0026 Inferred 060 0002
2.2.27		**Detachment fault—Concealed**			Fault **660 0010** Detachment 060 0026 Concealed 060 0003

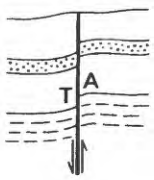
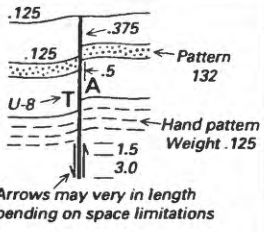
FAULT TRACES

Bar and ball symbol is preferred to U and D label, especially on complex maps.

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.2.28		**Fault—Queried where uncertain**	Used to show uncertainty of location as determined by compiler of map (not to be used on a fault drawn as a solid line)		Query **611 0100** Rotation 063 0xxx
2.2.29		**Fault—Bar and ball on downthrown side**	Bar and ball show downthrown side of fault		Bar and ball 611 0056 Rotation 063 0xxx
2.2.30		**Fault—Tick shows dip; U, upthrown side; D, downthrown side**	U and D show upthrown and downthrown sides of fault Either U and D or bar and ball may be used, but do not use both on one map		U 611 0115 D 611 0116
2.2.31 2.2.32	 	**Fault—Arrows show relative direction of movement** **Paired arrows are parallel to fault trace, tick shows dip, and angle arrow shows linear feature on fault surface**	Used on strike-slip or oblique-slip fault to show lateral movement. Also used in sections to show relative direction of movement Provide angle of dip to show a specific measurement	 	Left arrow 611 0050 Paired left arrows 611 0051 Right arrow 611 0052 Paired right arrows 611 0053 Rotation 063 0xxx

FAULTS IN GEOLOGIC SECTIONS

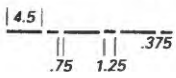
Symbols may be combined where complex movement can be demonstrated. In geologic sections, label faults in 7 pt type above profile.

2.2.33		**Fault—Showing relative direction of movement; T, toward observer; A, away from observer**	T and A show relative movement in relation to observer. Used in sections to indicate lateral movement normal to plane of section Arrows used in section to show relative direction of movement		T 611 0117 A 611 0118

T and A are used to label faults drawn in a cross section in order to indicate movements of blocks toward and away from the observer.

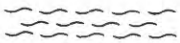
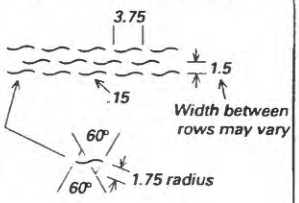
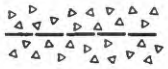
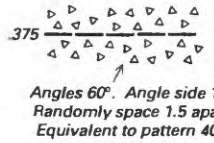
LINEAMENT

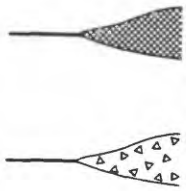
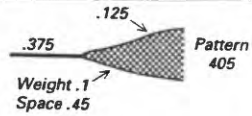
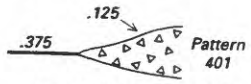
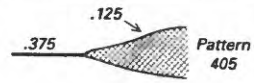
Lineament identified on aerial photograph or from remotely sensed imagery, but the origin is unknown.

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.2.34		**Lineament—Determined from aerial photographs or remotely sensed imagery**	Symbol used for linear feature that has not been identified on the ground		Lineament **660 0100**

2.3 SHEAR ZONES AND MYLONITE ZONES

Symbols and patterns are used to show zones of broken rock. Certain symbols are used as overprints on mapped rock units, and others are mapped units. The accuracy of the location of shear zones is shown graphically by the pattern of the line, in the same manner as for contacts.

2.3.1		**Shear zone**	Lines made up of S-shaped symbols represent narrow shear or mylonite zones that have indefinite boundaries (gradational) Areas may be patterned and spacing of symbols may be varied to indicate intensity of shearing		**660 0012**
2.3.2		**Zone of sheared rock—Showing fault in the zone**	Area of sheared rock within a mapped lithologic unit, limits approximate. Print over map unit color Fault may be drawn through an area that has a sheared rock overprint		**690 0012** 060 0001

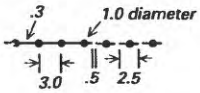
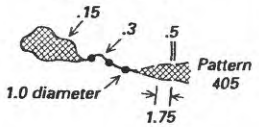
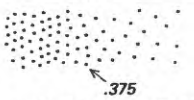
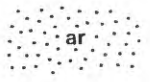
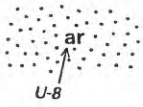
Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.3.3 2.3.4		**Sheared rock**	Fault zone or area of sheared rock that has defined boundaries too wide to be represented by a line at map scale. Pattern 401 may be substituted for pattern 405 (not an overprint but a black pattern that replaces rock unit colors and patterns)	  *Orient grid pattern at a 45° angle to trend of zone; do not use a dot pattern for sheared rock*	**690 0012**
2.3.5		**Sheared rock—Showing mineralization**	Show mineralized area of sheared rock within defined boundaries (black contacts) as red crosshatch pattern 405 or pattern 401	 *Orient grid pattern at a 45° angle to trend of zone; do not use a dot pattern for sheared rock*	**690 0012**

2.4 VEINS AND MINERALIZED AREAS

Codes are as follows:

Trace: 687 000T 071 000N. T is the number of the lookup table: N is the number of the entry designating the rock unit in the table.

Label: 618 000T 071 000N. T is the number of the lookup table; N is the number of the entry in the table for the plotted label.

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.4.1		**Vein—Dashed where approximately located, dotted where concealed**	Label near trace designates type of vein. Different kinds of veins may be shown in different colors		**687 000T** 071 000N Approximate 060 0001
2.4.2		**Mineralized stringers, veinlets**		*Specifications same as above, but spacing will vary* 	Concealed 060 0003
2.4.3		**Mineralized rock, altered rock—Dashed where approximately located**	Area of altered rock Distinguish type(s) of alteration by labels or different patterns (not a unit)	*Show as a pattern in magenta or red* 	Approximate **699 000T** 071 000N 060 0001
2.4.4		**Mineralized rock, altered rock**	Area of altered rock. Distinguish type(s) of alteration by labels or different patterns; show as an overprint on a mapped rock unit Higher density of stipple indicates a higher level of alteration	 *Randomly space about .875 apart. Increase spacing of dots where mineralization decreases*	**699 000T** 071 000N Approximate 060 0001 Concealed 060 0003
2.4.5		**Label ar indicates argillic alteration**	Labels refer to specific kinds of alteration		618 000T 071 000N

2.5 TRACES OF AXIAL SURFACES, CREST LINES, AND TROUGH LINES OF FOLDS

Traces of surfaces defined by fold structures can be represented by the axial surface or by the crest (highest points) and trough (lowest points) lines. The trace of the axial surface is preferred, but crest and trough traces may be substituted if specified in the map explanation. In rare cases, both may be shown if fully documented. The accuracy of location of the trace is indicated in the map by the pattern of the line, as for other lines. In general, fold traces are not located to the 1.00 mm (1/25 in) standard; this degree of accuracy can be expected only in areas of excellent exposure and abundant structural data. Lines representing fold traces on maps are drawn in red at a width of 0.25 mm; a line width of 0.20 mm may be substituted on crowded maps. Symbols representing axial surfaces or axes of minor folds should be shown in red as well.

A clear distinction in fold nomenclature applies throughout fold symbology. An anticline is a fold whose limbs close upward, and it contains the stratigraphically oldest layers in the core. An antiform is a fold in which the limbs close upward in layered rocks, but the stratigraphic succession in the core is unknown. A syncline is a fold that has its limbs closed downward and the stratigraphically youngest layers in its center. A synform is a fold in which the limbs close downward in layered rocks, but the stratigraphic succession in the core of the fold is unknown.

If traces of both axial surfaces and crest and trough lines are used in a single map (rare), label crest lines CS and trough lines TS. Remember that a fold *axis* is a linear feature, the intersection of the axial *surface* with a bedding surface and not the trace of the fold on the ground.

A tick drawn in the direction of dip of the surface and showing the dip angle may be added to traces that are solid lines or long dashes. An arrow to show the plunge of the fold may be added at the position of the observed or calculated plunge of the axis. Symbols are used to label traces in order to indicate the fold type.

The preferred phrasing used to describe traces of fold axial surfaces is:

> Anticline—Dashed where approximately located, short dashed where inferred, dotted where concealed, queried where uncertain

Codes for fold traces:

611 0030	Antiform
611 0031	Anticline
611 0036	Synform
611 0037	Syncline
611 0043	Monocline (single trace)

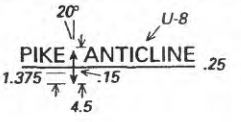
Codes to show accuracy:

060 0001	Approximately located
060 0002	Inferred
060 0003	Concealed

Codes for different types of folds:

060 0030	Fold, beds upright
060 0031	Overturned fold (beds on one limb overturned)
060 0032	Inverted fold (beds on both limbs overturned)
060 0033	Crest line
060 0034	Trough line
060 0035	Anticlinal bend of monocline
060 0036	Synclinal bend of monocline

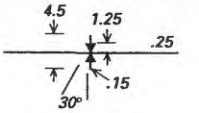
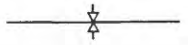
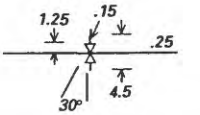
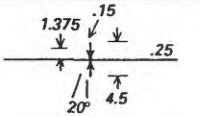
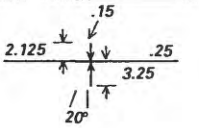
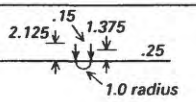
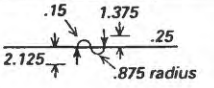
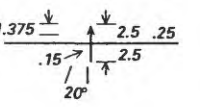
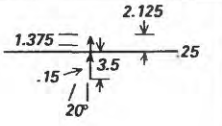
The trace of the fold axis and the label symbols that are used to indicate the type of the fold should be shown in red on maps where permanent red or magenta is used and where the colors of the rock units will not obscure these colors.

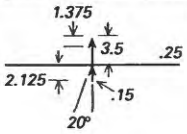
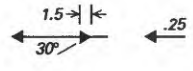
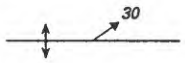
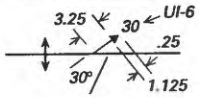
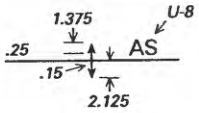
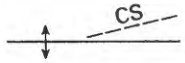
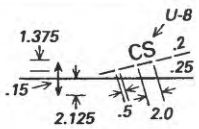
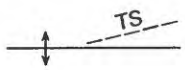
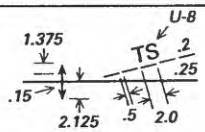
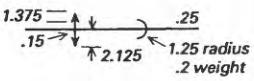
Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.5.1	PIKE ANTICLINE	**Anticline—Showing name**	Solid line indicates well-located trace of axial surface, but accuracy rarely meets 1.00 mm standard. Show name in color used for trace		**611 0031** Use code for accuracy as above

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.5.2		**Trace of axial surface of fold—Approximately located**		.5 .25 3.5	060 0001
2.5.3		**Trace of axial surface of fold—Inferred**	Center fold symbol on dashes. Fold symbol is perpendicular to the trace	.5 .25 1.5	060 0002
2.5.4		**Trace of axial surface of fold—Concealed**	Concealed trace used where trace is covered by other mapped units	.5 .25 .5	060 0003

FOLD TRACES

2.5.5		**Antiform**	Line used to label trace of axial surface of an antiform. Symbol showing type of fold is centered on the fold trace and is oriented perpendicular to the trace	4.5 1.25 .25 .15 60°	**611 0030** Arrow rotation 063 0xxx
2.5.6		**Antiform, second type**		4.5 .15 1.25 .25 60°	611 0030 Arrow rotation 063 0xxx Label 2 067 0002
2.5.7		**Anticline—Showing trace of axial surface**	The anticline symbol is centered on the fold trace for symmetric and open folds. For folds having near-vertical axial surfaces, the trace is independent of topography	4.5 1.375 .25 .15 20°	**611 0031** Arrow rotation 063 0xxx
2.5.8		**Asymmetric anticline—Showing trace of axial surface. Short arrow indicates steeper limb**	Beds are upright, and shorter arrow is on steeper limb	2.125 .25 3.25	**611 0032** Arrow rotation 063 0xxx
2.5.9		**Overturned anticline—Showing trace of axial surface and direction of dip of limbs**	Beds on one limb are overturned, and arrows show direction of dip of limbs	2.125 .25 1.0 radius .15	**611 033** Arrow rotation 063 0xxx
2.5.10		**Inverted anticline—Arrows show direction of dip of limbs**	Beds on both limbs are overturned, and arrows show direction of dip of limbs	.15 .25 2.125 .875 radius	**611 0034** Arrow rotation 063 0xxx

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.5.11		**Synform**	Symbol used to label trace of axial surface of a synform		**611 0036** Arrow rotation 063 0xxx
2.5.12		**Synform, second type**			**611 0036** Arrow rotation 063 0xxx Type 2 067 0002
2.5.13		**Syncline—Showing trace of axial surface**			**611 0037** 063 0xxx
2.5.14		**Asymmetric syncline—Showing trace of axial surface. Short arrow indicates steeper limb**	Beds are upright, and shorter arrow is on steeper limb		**611 0038** Arrow rotation 063 0xxx
2.5.15		**Overturned syncline—Showing trace of axial surface and direction of dip of limbs**	Beds on one limb are overturned, and arrows show direction of dip of limbs		**611 0039** Arrow rotation 063 0xxx
2.5.16		**Inverted syncline—Arrows show direction of dip of limbs**	Beds on both limbs are overturned, and arrows show direction of dip of limbs		**611 0040** Arrow rotation 063 0xxx
2.5.17		**Monocline—Showing trace of axial surface. Arrow indicates direction of dip**	Symbol used to label trace of a monocline is the maximum dip of the surface connecting the anticlinal and synclinal bends. The symbol is drawn by using a single line; anticlinal and synclinal bends too close together to draw as separate traces at map scale. Arrow points in direction of dip		**611 0041** Arrow rotation 063 0xxx
2.5.18		**Monocline—Anticlinal bend, showing shorter arrow on steeper beds**	Symbol used to label trace of an anticlinal bend of a monocline is drawn by using paired traces of folds; shorter arrow on steeper beds		**611 0042** Arrow rotation 063 0xxx

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.5.19		**Monocline—Synclinal bend, showing shorter arrow on steeper beds**	Symbol used to label trace of a synclinal bend of a monocline is drawn by using paired traces of folds; shorter arrow on steeper beds		**611 0043** Arrow rotation 063 0xxx
2.5.20		**Plunge of fold**	Symbol indicates general direction of plunge of fold. Plot at end of a trace or on trace; angle of plunge is not shown. Closely spaced symbols may be used to indicate plunge reversals		**611 0044** Arrow rotation 063 0xxx
2.5.21		**Trace of axial surface of fold—Showing direction and plunge of fold axis**	If, because of topography and the character of the fold, the trace of the axial surface differs significantly from the real direction of plunge, show direction and angle of plunge as a seperate arrow		Arrow **600 0070** Rotation 063 0xxx Plunge 064 00yy
2.5.22		**Label AS indicates trace of axial surface of fold**	Label AS indicates trace is axial surface of fold		**611 0046**
2.5.23		**Label CS indicates trace of crest line of fold where it diverges from trace of axial surface**	Label CS indicates trace is the crest line of fold		**611 0047**
2.5.24		**Label TS indicates trough line of fold where it diverges from trace of axial surface**	Label TS indicates trace is the trough line of fold		**611 0048**
2.5.25		**Fold having vertical or near-vertical axis—Shows direction of closure of fold limbs**	Symbol indicates direction of closure of fold		**611 0035**

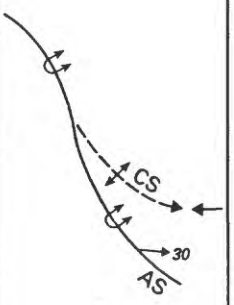
Symbols for domes and basins have become common on small-scale maps. These symbols are not appropriate to large-scale maps but are shown here for the sake of completeness.

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.5.26		Dome		1.375, 5.0, .15, 20°	630 0040
2.5.27		Basin		1.375, 2.125, 5.0, .15, 20°	630 0041

FOLD SYMBOLOGY

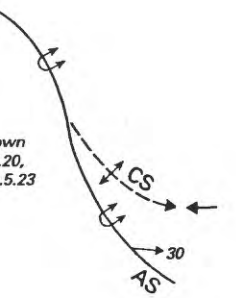
This example shows the use of the trace of both the axial surface (AS) and the crest line (CS) of an overturned anticline in order to show details of a complex fold.

2.5.28



Trace of fold surfaces—Trace of axial surface diverges to show trace of crest line and axial surface, where fold changes form at the core of an overturned anticline

Specifications shown as 2.5.7, 2.5.9, 2.5.20, 2.5.21, 2.5.22,and 2.5.23



Anticline	660 0030
Overturned axial trace	060 0031
Anticline	660 0030
Trace of crest line	060 0033
Approximate	060 0001
Overturned anticline	611 0033
Rotation	063 070
Overturned anticline	611 0033
Rotation	063 0038
Upright anticline	611 0031
Rotation	063 0048
Plunge arrow	600 0070
Rotation	063 0065
Plunge	064 0014
Label A	611 0046
Label C	611 0047
Plunge arrow point	611 0044
Rotation	063 0127
Plunge arrow point	611 0044
Rotation	063 0207

2.6 ISOPLETHS

Isopleths should be drawn by using line weights of 0.375 mm for principal contours and 0.20 mm for intermediate contours. These line weights may be reduced to 0.30 mm and 0.15 mm on maps with tightly spaced contours. On most maps, every fifth contour should be a principal contour and should be labeled with its numerical value. Isopleths are printed normally in red or another color that contrasts with most of the map information.

Codes:

656 ____ major code, 071 000N minor code to designate type (isopach, structure contour). Add 071 000N pair to designate unit, and add another 065 0mmm pair to designate value. Details and annotation must be provided in explanation.

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.6.1	——75——	**Line of equal thickness of geologic unit, aquifer, confining unit, saturated material; line of equal chemical value**	Print in red, brown, or blue (for aquifer)	UI-10 ↙ ——75—— .5	Isopach **640 0090** Unit name 071 000N
2.6.2	——100——	**Line of equal depth to geologic unit, aquifer, confining unit, bedrock, surface, or water surface**	Print in black Date information that varies with time	UI-8 ↙ ——100—— .3	Depth to bedrock **640 0095** Depth in meters 065 0mmm Depth to specified unit **640 0096** Unit name 071 000N Depth in meters 065 0mmm
2.6.3	——24——	**Line of equal (average or mean) precipitation (annual, monthly, or daily)**	Print in blue or black	——24—— .3	No coding assigned
2.6.4	——0.5——	**Line of equal (average or mean) runoff (annual, monthly, or daily)**	Print in blue or black	——0.5—— .3	No coding assigned
2.6.5	——100,000——	**Line of equal aquifer transmissivity or hydraulic conductivity.**	Print in blue or black Unit of transmissivity is *feet squared per day* and not "square feet per day"	——100,000—— .3	No coding assigned

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.6.6	——— 20 ———	**Line of equal water-level (change, rise, or decline)**	Print in blue or black If values of change are shown, all values other than zero must be preceded by a plus (+) or minus (-) sign	——— 20 ——— .3	No coding assigned
2.6.7	——— 5000 ———	**Line of equal physical or chemical property of water (specific conductance, pH, temperature, or chemical, radiochemical, or sediment concentration)**	Print in blue, orange, red, purple, or brown (sediment)	——— 5000 ——— .3	No coding assigned
2.6.8	——— 200 ——— ———————	**Line of equal intensity of potential field. Used in geophysical surveys (magnetic, gravity, or radioactivity)**	Print in black or red	——— 200 ——— .3 ——————— .15	No coding assigned

Lines of equal elevation of geologic unit surface (structure contours).

2.6.9	——— 600 ——— ———————	**First geologic surface**		UI-9 ——— 600 ——— .375 ——————— .2	**640 0092** 650 ffff
2.6.10	——— 600 ——— ———————	**Second geologic surface**	Print in red or second color to distinguish different surfaces	——— 600 ——— .375 ——————— .2	**640-0094** 650 ffff

Faults that displace structure contours in the subsurface should be shown projected vertically upward from the position of offset to the surface of the Earth. Such fault lines are used only on maps that have structure contours and are shown in the same color as structure contours. May be shown on black-and-white maps as a line 0.50 mm wide, screened 50 percent black. Code as below.

2.6.11	----------	**Concealed fault—Locations of points where fault breaks structure contours projected to Earth's surface**		Weight .375 ---------- Dash .5 Space .5	**664 027**

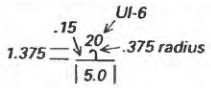
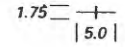
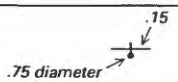
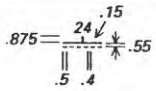
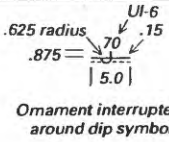
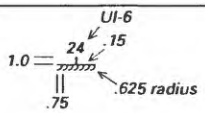
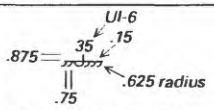
2.7 SYMBOLS FOR MINOR STRUCTURES

All symbols should be plotted by using a line weight of 0.15 mm. All strike lines for planar features and all arrow lengths for linear features at standard size are 5.0 mm long. The index point (point of observation) for symbols representing surfaces is located at the midpoint of the strike line; for symbols representing linear features, the index point is at the nock end of the arrow. Symbols may be drawn at 80 percent of the standard size if required for clarity of graphic presentation on crowded maps. All symbols on a map should be drawn at the same size, so match and do not mix sizes. Numbers for dip should be 6 pt. If symbols are drawn at 80 percent of the standard size, reduce type size to 5 pt.

2.7 MEASUREMENTS OF BEDDING SURFACE

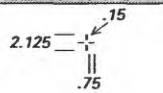
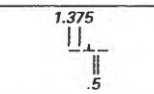
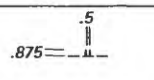
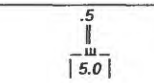
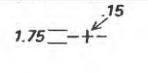
On some geologic maps, the top of vertical beds has been shown by printing the number 90 (meaning vertical) on the stratigraphic top side of the standard symbol for vertical beds; we do not recommend this practice. An arrow having a dot at the end opposite to the arrow point has been used to give apparent dip of beds on some maps, but this symbol should not be used; all symbols should show true dip. The author of the map is in a far better position to compute true strike and dip than the reader is.

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.7.1	⊕	**Horizontal beds**	Sedimentary rocks	⊕ ← 2.5 diameter, .15 weight	**600 0001** 064 0000
2.7.2	—	**Inclined beds—Showing strike and direction of dip**		.875, .15, | 5.0 |	**600 0001** 063 0xxx
2.7.3	—'—	**Inclined beds—Showing approximate strike and direction of dip**	Uncertainty is for measured values, not the location of observation	.75, .15, .25, 2.0	**600 0003** 063 0xxx 064 00yy
2.7.4	40	**Inclined beds—Showing strike and dip**		.15, 40, UI-6, .875, .5, | 5.0 |	**600 0001** 063 0xxx 064 00yy
2.7.5	55	**Inclined and crenulated or warped beds—Showing approximate strike and dip**		.15, 55, UI-6, .875, .375 radius, | 5.0 |	**600 0002** 063 0xxx 064 00yy
2.7.6	30	**Inclined beds—Showing strike and dip. Top of beds known from local features**		.15, UI-6, 30, .75 diameter, .875, | 5.0 |	**600 0004** 063 0xxx 064 00yy
2.7.7	65	**Overturned beds—Showing strike and dip**		UI-6, .15, 65, .875, .625 radius, | 5.0 |	**600 0005** 063 0xxx 064 00yy
2.7.8	65	**Overturned beds—Showing strike and dip. Top of beds known from local features**	Use only on maps where top direction may be in doubt	UI-6, .15, 65, .625 radius, .875, .75 diameter, | 5.0 |	**600 0006** 063 0xxx 064 00yy

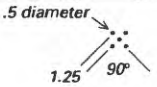
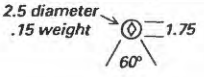
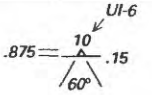
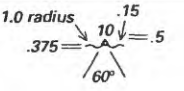
Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.7.9		**Beds overturned more than 180 degrees—Showing strike and dip**			600 0007 063 0xxx 064 00yy
2.7.10		**Vertical beds—Showing strike**			0600 0001 063 0xxx 064 0090
2.7.11		**Vertical beds—Showing strike and direction of top of beds; top known from local features**	Use on maps where top direction may be in doubt		0600 0004 063 0xxx 064 0090
2.7.12		**Graded bedding**			**600 0001** 063 0xxx 064 00yy Ornament 070 0001
2.7.13		**Overturned graded bedding**			**600 0005** 063 0xxx 064 00yy Ornament 070 0002
2.7.14		**Attitude of bedding in crossbedded rocks**			**600 0001** 063 0xxx 064 00yy Ornament 070 0003
2.7.15		**Attitude of bedding in overturned and crossbedded rocks**			**600 0005** 063 0xxx 064 00yy Ornament 070 0004

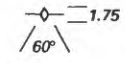
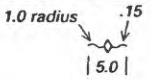
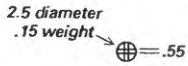
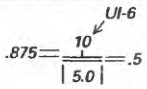
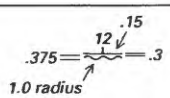
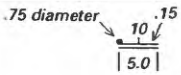
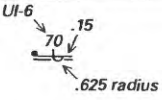
MEASUREMENTS OF BEDDING SURFACES FROM AERIAL PHOTOGRAPHS

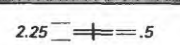
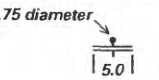
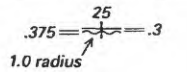
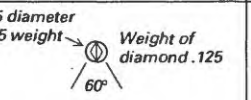
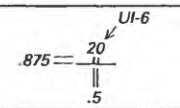
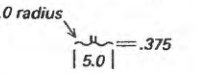
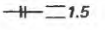
Symbols for the strike and dip of beds determined from aerial photographs may be used on reconnaissance geologic maps. These should not be used on standard geologic maps. Such measurements should be checked in the field, and after verification, standard strike and dip symbols should be employed. These symbols are shown below for the sake of completeness.

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.7.16	⊹	**Horizontal beds**			Attitude from image **600 0010** Symbol 061 0129
2.7.17	–⊥–	**Gently inclined beds**	Dip determined as >0°–30°		Attitude from image **600 0010** Symbol **061 0130**
2.7.18	–⩫–	**Moderately inclined beds**	Dip determined as >30°– 60°		Attitude from image **600 0010** Symbol **061 031**
2.7.19	–⩫–	**Steeply inclined beds**	Dip determined as >60°– <90°		Attitude from image **600 0010** Symbol **061 0132**
2.7.20	–+–	**Vertical and near-vertical beds**			Attitude from image 600 0011 Symbol 061 0133

2.8 FOLIATION AND LAYERING IN IGNEOUS ROCK

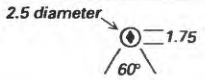
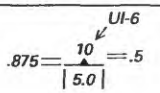
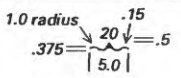
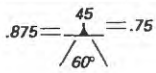
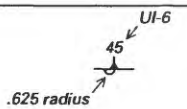
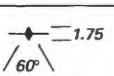
2.8.1	⁘	**Massive igneous rock**	Foliation and lineation are absent. Symbol used to show that observation has been made at the locality indicated		**600 0018**
2.8.2	⊙	**Horizontal foliation in igneous rock**	Horizontal flow foliation or layering in igneous rock		**600 0020** 064 0000
2.8.3	10	**Inclined foliation in igneous rock—Showing strike and dip**	Inclined flow foliation or layering in igneous rock. If dip angle is omitted, symbol indicates general direction of dip		**600 0020** Rotation 063 0xxx Dip 064 00yy
2.8.4	10	**Crinkled or deformed foliation in igneous rock—Showing strike and dip**			**600 0022** Rotation 063 0xxx Dip 064 00yy

Reference Number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.8.5		**Vertical foliation in igneous rock—Showing strike**	Strike of vertical flow foliation or layering in igneous rock		**600 0020** Rotation 063 0xxx Dip 064 0090
2.8.6		**Vertical or near-vertical crinkled or deformed foliation in igneous rock—Showing approximate strike**	Folded or warped flow foliation in igneous rock		**600 0022** Rotation 063 0xxx Dip 064 00yy
2.8.7		**Horizontal cumulate foliation in layered igneous rock**			**600 0024** 064 0000
2.8.8		**Inclined cumulate foliation in layered igneous rock—Showing strike and dip**	If dip angle is omitted, symbol indicates general direction of dip		**600 0024** Rotation 063 0xxx Dip 064 00yy
2.8.9		**Crinkled or deformed cumulate foliation in layered igneous rock—Showing approximate strike and dip**			**600 0025** Rotation 063 0xxx Dip 064 00yy
2.8.10		**Inclined cumulate foliation parallel to upright layering in igneous rock—Showing strike and dip. Top of layers known from local features**			**600 0026** Rotation 063 0xxx Dip 064 00yy
2.8.11		**Inclined cumulate foliation parallel to overturned layers in igneous rock— Showing strike and dip. Top of layers known from local features**			**600 0027** Rotation 063 0xxx Dip 064 00yy

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.8.12		**Vertical cumulate foliation or layering in igneous rock—Showing strike**			**600 0024** Rotation 063 0xxx Dip 064 0090
2.8.13		**Vertical cumulate foliation in igneous rock—Showing strike and direction of top of layers known from local features**			**600 0023** Rotation 063 0xxx Dip 064 0090
2.8.14		**Vertical or near-vertical crinkled or deformed cumulate foliation or layering in igneous rock—Showing approximate strike and dip**			**600 0025** Rotation 063 0xxx Dip 064 00yy
2.8.15		**Horizontal compaction foliation in ash-flow tuff**			**600 0028** 064 0000
2.8.16		**Inclined foliation in ash-flow tuff**			**600 0028** Rotation 063 0xxx Dip 064 00yy
2.8.17		**Crinkled or deformed compaction foliation in ash-flow tuff—Showing approximate strike**			**600 0029** Rotation 063 0xxx Dip 064 00yy
2.8.18		**Vertical or near-vertical compaction foliation in ash-flow tuff—Showing strike**			**600 0028** Rotation 063 0xxx Dip 064 0090

2.9 FOLIATION AND LAYERING IN LAYERED METAMORPHIC ROCK

The symbols provided below apply to all layered metamorphic rocks. The text uses layered gneisses as the principal example.

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.9.1		**Horizontal foliation in layered gneiss**			**600 0011** 064 0000
2.9.2		**Horizontal foliation parallel to bedding in layered gneiss**			600 0001 064 0000 600 0010 064 0000
2.9.3		**Inclined foliation in layered gneiss—Showing strike and dip**	If dip angle is omitted, symbol indicates general direction of dip		**600 0011** Rotation 063 0xxx Dip 064 00yy
2.9.4		**Crinkled or deformed foliation in layered gneiss—Showing approximate strike and direction of dip**			**600 0012** Rotation 063 0xxx Dip 064 00yy
2.9.5		**Inclined foliation parallel to upright beds in layered gneiss—Showing strike and dip. Top of beds known from local features**			**600 0014** Rotation 063 0xxx Dip 064 00yy
2.9.6		**Inclined foliation parallel to overturned beds in layered gneiss—Showing strike and dip. Top of beds known from local features**			**600 0016** Rotation 063 0xxx Dip 064 0yyy
2.9.7		**Vertical foliation in layered gneiss—Showing strike**			**600 0010** Rotation 063 0xxx Dip 064 0090
2.9.8		**Vertical foliation in layered gneiss—Showing strike and direction of dip. Top of beds known from local features**	Dot indicates top of beds		**600 0014** Rotation 063 0xxx Dip 064 0yyy

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.9.9		**Vertical or near-vertical crinkled or deformed folation in layered gneiss—Showing approximate strike**		1.0 radius .375 | 5.0 |	**600 0012** Strike 063 0xxx Dip 064 00yy

2.10 JOINTS

The accuracy of location is indicated by the pattern of the line, as for contacts and faults.

The preferred phrasing used for traces of joints is:

Joint (or master joint)—Dashed where approximately located

Use symbols having filled boxes for joints unless two sets are to be distinguished. Use open boxes for joints of a second type. Provide definitions of both types in the explanation, such as mineralized, second generation, or the like.

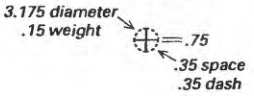
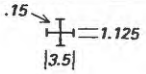
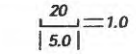
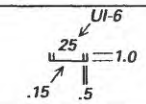
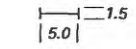
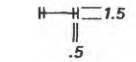
If observations of several joints are made at the same locality, the strikes and dips of the several joints may be shown as illustrated below. The locality of observation is the point of junction of the strike line. Rotation value is degrees clockwise from north (from 0°). Index point is the site of measurement and is the point common to all the strike lines in symbols for multiple joints.

2.10.1		**Horizontal joint**	Type 1 joint if two types are present	2.375 diameter 1.125	**600 032** 064 0000
2.10.2		**Horizontal joint**	Type 2 joint	2.375 diameter 1.125 .15	**600 032** 064 0000 067 0002
2.10.3	30	**Inclined joint—Showing strike and dip**	Type 1 joint if two types are present	UI-6 .625 30 | 5.0 |	**600 032** Rotation 063 0xxx Dip 064 00yy
2.10.4	35	**Inclined joint—Showing strike and dip**	Type 2 joint	.15 .5 35 | 5.0 |	**600 032** Rotation 063 0xxx Dip 064 00yy 067 0002
2.10.5		**Vertical joint—Showing strike**	Type 1 joint if two types are present	1.25 1.125	**600 032** Rotation 063 0xxx Dip 064 0090
2.10.6		**Vertical joint—Showing strike**	Type 2 joint	.15 | 5.0 |	**600 032** Rotation 063 0xxx Dip 064 0090 067 0002
2.10.7	5	**Trace of joint—Dashed where approximately located**	Traces of joints are mapped to show important joint systems in areas of abundant outcrop Ticks may be added to show dip for any surface	Draw in black UI-6 5 1.75 .15 Length may vary .5 Width may vary 1.75	Joint **660 0014** Approximate 060 0001

Examples of use for multiple joints				
Symbol	**Description**	**Notes on usage**	**Cartographic specifications**	**Codes**
	**Multiple joints of a single generation**	Sequence of codes listed clockwise from 0 degrees		Joint symbol 600 0032 Rotation 063 0020 Dip 064 0060 Index point 068 0001 Joint symbol 600 032 Rotation 063 0062 Dip 064 0054 Index point 068 0001 Joint symbol 600 032 Rotation 063 0115 Dip 064 0090 Index point 068 0001 Joint symbol 600 032 Rotation 063 0146 Dip 064 0048 Index point 068 0001
	**Multiple joints of two different types**			Joint symbol 600 032 Rotation 063 0340 Dip 064 0048 Symbol type 067 0002 Index point 068 0001 Joint symbol 600 032 Rotation 063 0110 Dip 064 0055 Index point 068 0001 Joint symbol 600 032 Rotation 063 0205 Dip 064 0090 Symbol type 067 0002 Index point 068 0001 Joint symbol 600 032 Rotation 063 0300 Dip 064 0045 Index point 068 0001

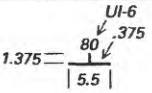
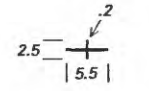
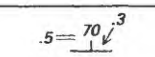
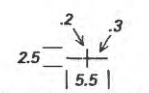
2.11 ROCK CLEAVAGE

If two or more types of cleavage are distinguished, all types should be described clearly in the explanation, that is, as slip, shear, or axial surface cleavage. Plot all symbols by using a line width of 0.15 mm; strike line and lines of cross, 5.00 mm long; ticks, 1.00 mm long.

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.11.1		**Horizontal cleavage**	Type 1 cleavage if two types are present		**600 0030** 064 0000
2.11.2		**Horizontal cleavage**	Type 2 cleavage		**600 0030** 064 0000 067 0002
2.11.3		**Inclined cleavage—Showing strike and dip**	Type 1 cleavage if two types are present		**600 0030** Rotation 063 0xxx Dip 064 00yy
2.11.4		**Inclined cleavage—Showing strike and dip**	Type 2 cleavage		**600 0030** Rotation 063 0xxx Dip 064 0002
2.11.5		**Vertical cleavage—Showing strike**	Type 1 cleavage if two types are present		**600 0030** Rotation 063 0xxx Dip 064 0090
2.11.6		**Vertical cleavage—Showing strike**	Type 2 cleavage		**600 0030** Rotation 063 0xxx Dip 064 0090 067 0002

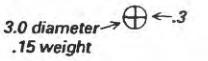
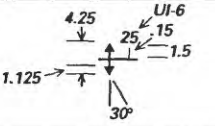
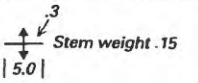
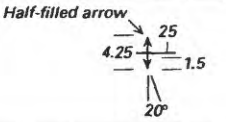
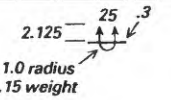
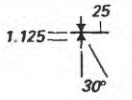
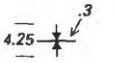
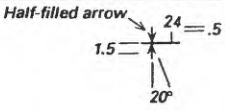
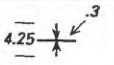
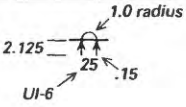
2.12 MINOR FAULTS AND VEINS

Symbols representing observations of minor faults and veins are most useful when representing restricted data, such as observations made at roadcuts in terrain where minor faults and veins cannot be traced.

2.12.1		**Minor fault(s)—Showing strike and dip**	Symbol used for fractures having displacement that is in contrast to joints Print in black		**600 0009** Rotation 063 xxxx Dip 064 00yy
2.12.2		**Minor fault(s)—Vertical**			**600 0009** Rotation 063 0xxx Dip 064 0090
2.12.3		**Vein(s)—Showing strike and dip**	Minor veins or mineralized fractures Print in color, but not in red or black, to show type of mineralization; screen 50 percent on black-and-white maps		**600 0031** Rotation 063 0xxx Dip 064 00yy
2.12.4		**Minor vein(s)—Vertical**		 *Normally shown in color*	**600 0031** Rotation 063 0xxx Dip 064 0090

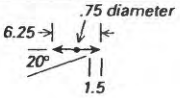
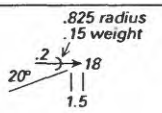
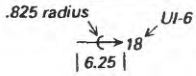
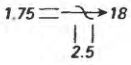
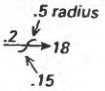
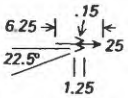
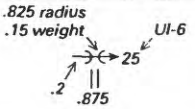
2.13 AXIAL SURFACES OF MINOR FOLDS

Print symbols in permanent red or magenta unless the colors of the rock units would obscure them (if so, print in black).

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.13.1		**Minor fold—Horizontal axial surface**			**600 0033** 064 0000
2.13.2		**Minor antiform—Inclined axial surface**			**600 0034** Rotation 063 0xxx Dip 064 00yy
2.13.3		**Minor antiform—Vertical axial surface**			**600 0034** Rotation 063 0xxx Dip 064 0090
2.13.4		**Minor anticline—Inclined axial surface**			**600 0035** Rotation 063 0xxx Dip 064 00yy
2.13.5		**Minor anticline—Vertical axial surface**			**600 0035** Rotation 063 0xxx Dip 064 0090
2.13.6		**Minor overturned anticline—Inclined axial surface**			**600 0036** Rotation 063 0xxx Dip 064 00yy
2.13.7		**Minor synform—Inclined axial surface**			**600 0037** Rotation 063 0xxx Dip 064 00yy
2.13.8		**Minor synform—Vertical axial surface**			**600 0037** Rotation 063 0xxx Dip 064 0090
2.13.9		**Minor syncline—Inclined axial surface**			**600 0038** Rotation 063 0xxx Dip 064 00yy
2.13.10		**Minor syncline—Vertical axial surface**			**600 0038** Rotation 063 0xxx Dip 064 0090
2.13.11		**Minor overturned syncline—Inclined axial surface**			**600 0039** Rotation 063 0xxx Dip 064 00yy

2.14 AXES OF MINOR FOLDS

Print symbols in permanent red or magenta unless the colors of the rock units would obscure them (if so, print in black).

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.14.1		**Horizontal minor fold axis**	Symbol used separately or in combination with symbols for axial surfaces of minor folds		**600 0040** Rotation 063 0xxx Plunge 064 0000
2.14.2		**Inclined minor fold axis**			**600 0040** Rotation 063 0xxx Plunge 064 00yy
2.14.3		**Vertical minor fold axis**			**600 0040** 064 0090
2.14.4		**Minor anticline—Showing bearing and plunge**			**600 0041** Bearing 063 0xxx Plunge 064 00yy
2.14.5		**Minor syncline—Showing bearing and plunge**			**600 0042** Bearing 063 0xxx Plunge 064 00yy
2.14.6		**Minor fold, dextral—Showing bearing and plunge**	Minor fold that has dextral rotation sense, so fold viewed down the axis has Z-shaped asymmetry		**600 0043** Bearing 063 0xxx Plunge 064 00yy
2.14.7		**Minor fold, sinistral—Showing bearing and plunge**	Minor fold that has sinistral rotation sense so fold viewed down the axis has S-shaped asymmetry		**600 0044** Bearing 063 0xxx Plunge 064 00yy
2.14.8		**Minor folds—Showing bearing and plunge**	Minor fold axes that have no sense of symmetry or asymmetry inferred		**600 0045** Bearing 063 0xxx Plunge 064 00yy
2.14.9		**Boudinage—Showing bearing and plunge**			**600 0068** Bearing 063 0xxx Plunge 064 00yy

2.15 LINEAR FEATURES

The list below includes some of the kinds of linear features that may be used on geologic maps. In this list, B lineations parallel minor folds, and A lineations are in the direction of slip. The plunge angle should be given wherever known. Coding for rotation and posted angle are not shown for all the symbols below.

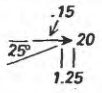
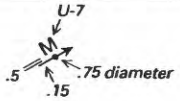
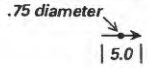
Codes for types of lineation:

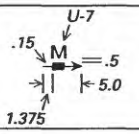
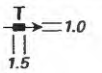
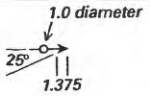
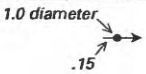
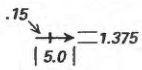
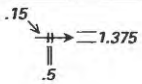
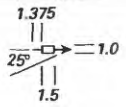
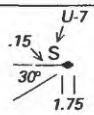
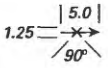
060 0051 Aligned elongate minerals

060 0052 Aligned minerals or streaks

Lineation systems:

600 ____Minor fold axes (use codes on previous pages)

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.15.1		**Lineation—Showing bearing and plunge**	Linear feature but type not designated. Used generally in combination with a symbol representing a planar feature		**600 0050** Bearing 063 0xxx Plunge 064 00yy
2.15.2		**Horizontal lineation**	Lineation, type not designated		**600 0050** 063 0xxx 064 0000
2.15.3		**Vertical lineation**	Lineation, type not designated		**600 0050** 064 0090
2.15.4		**Lineation, mineral**	Aligned elongate minerals on a foliation surface that is parallel to minor folds (B lineation)		**600 0051** 063 0xxx 064 00yy
2.15.5		**Lineation, mineral streaks**	Aligned mineral streaks on a foliation surface (A lineation)		**600 0052**
2.15.6		**Slip lineation**	Slip lineation, groove, or striations on a foliation surface		**600 0053**
2.15.7		**Flow lineation**	Linear feature on flow foliation surface in direction of flow (A lineation)		**600 0055**
2.15.8		**Lineation, flow folds**	Minor fold axes formed by flow (B lineation)		**600 0056**

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.15.9		**Flow direction**	Linear feature oriented by flow, such as an aligned spindle-shaped xenolith		**600 0057**
2.15.10		**Lineation—Aligned mineral grains in cumulate rocks**			**600 0058**
2.15.11		**Lineation—Trough banding in cumulate rocks**			**600 0059**
2.15.12		**Lineation—Flow direction in ash-flow tuff**			**600 0060**
2.15.13		**Lineation—Minor folds normal to flow in ash-flow tuff**			**600 0061**
2.15.14		**Lineation at intersection of bedding and cleavage—Showing bearing and plunge**			**600 0062**
2.15.15		**Lineation at intersection of foliation and cleavage—Showing bearing and plunge**			**600 0063**
2.15.16		**Lineation on cleavage surface—Showing bearing and plunge**			**600 0064**
2.15.17		**Slip lineation on a fault or shear surface—Showing bearing and plunge**	Use for a feature such as a slickenside indicating direction of offset		**600 0065**
2.15.18		**Penetrative lineation—Showing bearing and plunge in combination with foliation symbol**	Used in combination with foliation symbol. Element is not a lineation on a foliation surface		**600 0067**

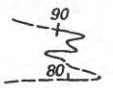
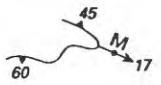
2.16 FREE–FORM FOLD SYMBOLOGY

Some published maps have used diagrammatic symbols to represent structures in complexly deformed rocks. In many cases, this kind of symbol would seem to convey a meaning more clearly to the author of the map than to the map reader. Special use has been made of these kinds of symbols in terranes where outcrops are few and far between, perhaps so that the author can graphically portray everything observed on a small outcrop after its covering of moss has been removed. In most cases, the spatial reference of the symbol is tenuous; diagrammatic lines representing fold limbs extend over areas far from the site of observation. Examples are shown below. These symbols should be printed according to specifications shown in 2.14.

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.16.1		**Open anticlinal fold**		*Specifications shown as 2.15.1*	No coding assigned
2.16.2		**Tight anticlinal fold**			No coding assigned
2.16.3		**Open synclinal fold**			No coding assigned
2.16.4		**Tight synclinal fold**			No coding assigned
2.16.5		**Complex fold—Showing direction and plunge. Triangle indicates dip of foliation; tick indicates dip of beds**			No coding assigned
2.16.6		**Isoclinal fold**			No coding assigned

Symbols such as the above seem to have certain common characteristics, but no two symbols are quite alike. The place of observation is not well specified. No two authors use such forms in the same way. The spatial definition required by the representation as digital objects is misleading. Such symbols belong outside the map area in diagrammatic sketches that are referenced, perhaps by a locality number, to their place on the map.

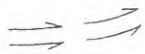
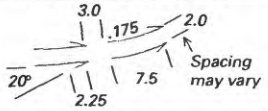
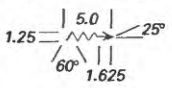
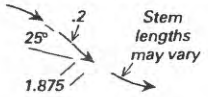
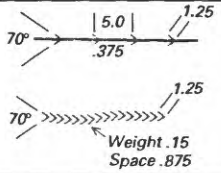
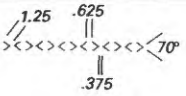
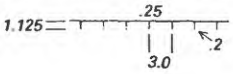
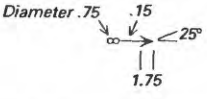
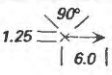
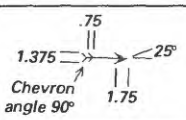
By contrast, representations such as the actual trace of a bed on the land surface, which is used as a form line to show the structure, are encouraged in order to provide detail that is not shown by contacts between rock units. The addition of symbols that show the plunge of folds and the attitude of the bed at a place of observation may also be valuable. The spatial reference of such lines as digital objects is accurate. Solid and patterned lines should be used to show the accuracy of location.

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.16.7		**Trace of iron-formation—Thin bed used as a key bed to show structure and dip, dashed where inferred**		*Specifications shown as 2.1.20, 2.7.4, and 2.7.10*	No coding assigned
2.16.8		**Trace of gneiss—Resistant bed that can be mapped locally to show structural detail, including dip of foliation and bearing and plunge of mineral lineation**		*Specifications shown as 2.1.20, 2.9.3, and 2.15.4*	No coding assigned

SPECIALIZED GEOLOGIC MAP SYMBOLS

2.17 FLUVIAL , GLACIOFLUVIAL, AND ALLUVIAL FEATURES

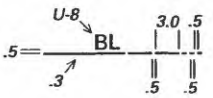
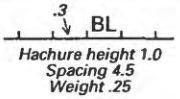
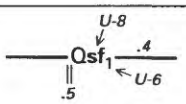
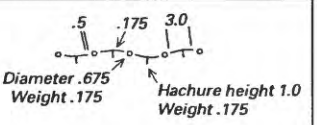
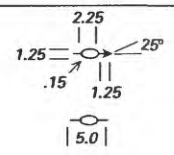
Show fluvial and glaciaofluvial features in blue unless noted otherwise; screen to 50 percent on black-and-white maps.

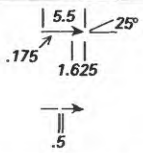
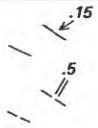
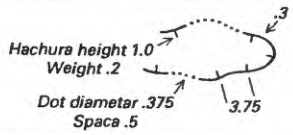
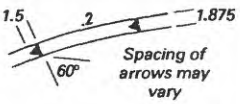
Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.17.1		**Glacial (meltwater) channel—Abandoned**			**640 0040**
2.17.2		**Meltwater spillway—Site of spillway that controlled the deposition of glacial-lake and glacial-stream deposits**			**640 0031**
2.17.3		**Flow direction of glacial stream—Showing general direction of flow determined from stream-channel patterns**	Symbols follow trend of major glacial drainage		**640 0041**
2.17.4		**Kame terrace scarp—Hachures point downscarp**			**640 0042**
2.17.5		**Esker—Chevrons point in direction of transport**	Show chevron symbols in blue; use chevron symbols in black on black-and-white maps		**640 0044**
2.17.6		**Esker—Transport direction unknown**			**640 0045**
2.17.7		**Fluvial terrace scarp—Hachures point downscarp**			**640 0046**
2.17.8		**Fluvial transport direction**			**600 0075**
2.17.9		**Sediment transport direction— Determined from imbrication**			**600 0076**
2.17.10		**Sediment transport direction—Determined from crossbeds**			**600 0077**
2.17.11		**Sediment transport direction— Determined from flute casts**			**600 0078**

2.18 GLACIAL FEATURES

Glacial, periglacial, and glaciofluvial features have been treated in a variety of ways on published maps. Mappable units require no special treatment. Symbols (patterns) for some features generally are superposed on mapped rock units. Coding for a glacier or snowfield is part of the combined hydrography code set.

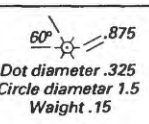
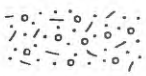
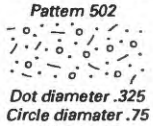
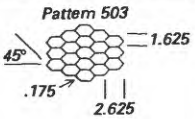
Symbols for minor features represent field measurements. Show in black, red, or blue; screen to 50 percent on black-and-white maps. Symbols may be shown at one-half size on small-scale maps. Multiple observations may be shown at a single locality.

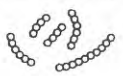
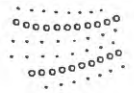
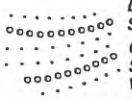
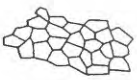
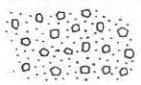
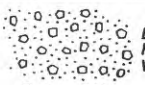
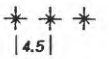
Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.18.1	BL	**Glacial limit or terminus—Dashed where approximately located, dotted where concealed, showing label of glacial stage on glacier side of boundary line (BL, Bull Lake)**	Terminus lines mostly are shown in color (red, blue,or green) to identify different glacial advances. Show name in color used for boundary		**640 0036** 060 0001 060 0003 060 0003
2.18.2	BL	**Limit of significant glacial advance—Showing name (BL, Bull Lake)**	Limits of glacial advance normally are shown on small-scale maps. Ticks point toward glaciated area		**640 0038** 060 0001
2.18.3	Qsf_1	**Retreatal position of stagnant ice margin—Approximate position of ice during deposition of designated unit. Dashed where inferred**	Show in purple		
2.18.4		**Crest line of moraine**	Show in blue		**640 0035**
2.18.5		**Crest line of asymmetrical moraine—Ticks point down steeper slope**	Show in blue		**640 0034**
2.18.6		**Ridges on moraine**	Show in blue		**640 0037**
2.18.7		**Ice-molded landform—Drumlin or drumloid form**	Indicate flow direction by using arrow as needed Show in blue		**600 0071** Direction 063 0xxx

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.18.8		**Glacial striations—Showing bearing or direction of flow. Broken where older**	Show in blue		**600 0072** Direction 063 0xxx
2.18.9		**Glacial striations—Showing bearing of flow, direction of flow unknown. Broken where older**	Show in blue		**600 0074** Direction 063 0xxx 600 0073
2.18.10		**Cirque headwall**	Ticks point into cirque Ticks point in both directions on a serrated ridge between two cirques. Show in black or blue		**640 0039**
2.18.11		**Margin of glacially scoured basin—Dotted where concealed**	Ticks point into basin Show in blue		**640 0033** 060 0003
2.18.12		**Glacial flow—Showing direction and path determined from geologic evidence**	Show in blue		**640 0032**
2.18.13		**Ice contact slope—Showing line pattern oriented downslope**	Show in blue		**690 0048**

2.19 PERIGLACIAL FEATURES

Show periglacial features in blue; screen to 50 percent on black-and-white maps.

2.19.1		**Pingo**	If large enough, show as an area instead of using this symbol		**630 0030**
2.19.2		**Periglacial patterned ground**			**690 0031**
2.19.3		**Polygonal patterned ground**			**690 0032**

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.19.4		**Sorted circles**		 *Diameter .95* *Weight .15*	**690 0033**
2.19.5		**Stone stripes**		 *Dot diameter .375* *Space 1.25–1.5* *Circle diameter .75* *Space .45* *Weight .15*	**690 0034**
2.19.6		**Solifluction lobes**		*Radius .9* *Weight .15* *.925*  *Pattern 504*	**690 0035**
2.19.7		**Ice-wedge polygons**		*Weight .15*  *Pattern 505*	**690 0036**
2.19.8		**Felsenmeer**		 *Dot diameter .25* *Polygons 1.0–1.5* *Weight .15* *Pattern 506*	**690 0037**
2.19.9		**Thermokarst depression**	Ticks point into depression	*.175*  *Hachure height 1.0* *Spacing 1.75*	**690 0039**
2.19.10		**Kettle (ice-block depression)**		*45°* *3.0* *1.75* *Weight .15*	**630 0036**
2.19.11		**Aligned kettles—Showing linear trend**		 *4.5*	**630 0037**

2.20 LACUSTRINE AND MARINE FEATURES

Additional codes to use with traces below:

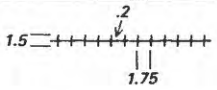
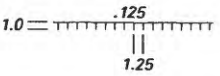
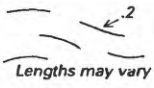
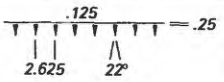
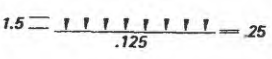
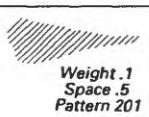
060 0001 Approximately located
060 0002 Inferred
060 0003 Concealed

For recent features, show dates of traces below by using major code 0071 and a minor code such as the date of the year (if more information is needed about a feature, see the major code in a lookup table):

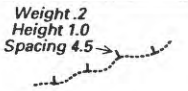
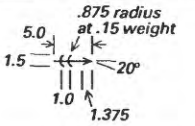
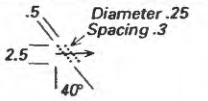
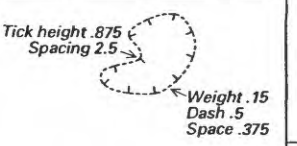
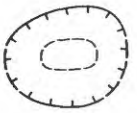
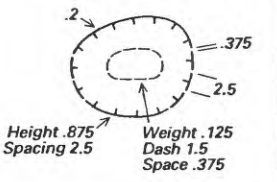
071 aaaa Example: 071-1994

Codes for labels:

611 0130 Label ML (marine limit)
611 0132 Label SL (shoreline)

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.20.1		**Former shoreline of marine limit or lake shoreline**			**640 0070**
2.20.2		**Spit or bar—Trace follows axis**			**640 0072**
2.20.3		**Shoreline cliff**	Line follows cliff top, and ticks point down the cliff		**640 0074**
2.20.4		**Beach ridges**	Trace follows top of ridge Commonly drawn in blue		**640 0078**
2.20.5		**Aggradational shoreline**	Line follows shoreline, and symbols are offshore Show in blue		**640 0080**
2.20.6		**Erosional shoreline**	Line follows shoreline, and symbols are offshore Show in blue		**640 0082**
2.20.7		**Marine-abrasion platform**	Pattern in blue		**690 0040**

2.21 EOLIAN FEATURES

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.21.1		**Dune crest**	Crest of dune shown by dotted line (dots small and closely spaced). Dune forms shown by traces of crests		**640 0050**
2.21.2		**Dune crest—Ticks point downscarp on slip face**	Crest of dune shown by dotted line. Ticks point down the slip face of the dune		**640 0051**
2.21.3		**Sediment transport direction—Determined from dune forms**			**600 0080**
2.21.4		**Sediment transport direction—Determined from eolian crossbedding in vertical or near-vertical section**			**600 0081**
2.21.5		**Sediment transport direction—Determined from dune bedding in horizontal section**			**600 0082**
2.21.6		**Blowout rim—Closed depression of eolian origin in a dune field**	Floor may be mapped as appropriate to individual feature		**640 0055**
2.21.7		**Blowout rim—Closed depression of eolian origin in bedrock; inner dashed line shows edge of a dry lakebed**			**640 0056**

2.22 LANDSLIDES AND MASS-WASTING FEATURES

Additional codes to use with traces:

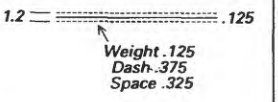
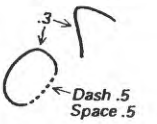
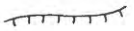
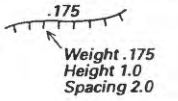
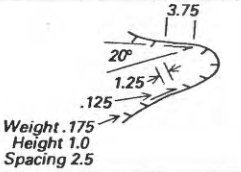
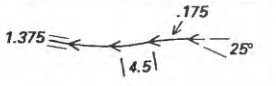
060 0001 Approximately located
060 0002 Inferred
060 0003 Concealed

For recent features, show dates of traces below by using major code 0071 and a minor code such as the date of the year (if more information is needed about a feature, see the major code in a lookup table):

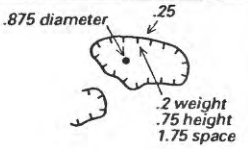
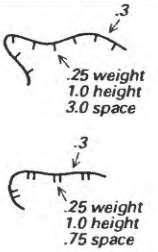
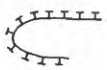
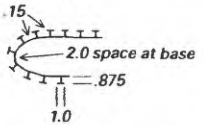
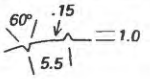
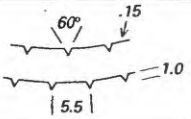
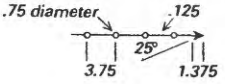
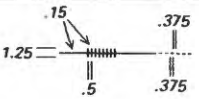
071 aaaa Example: 071 1994

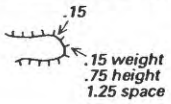
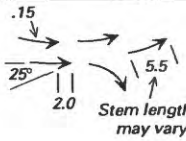
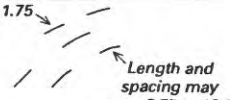
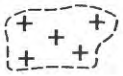
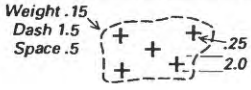
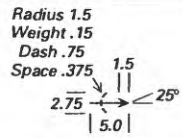
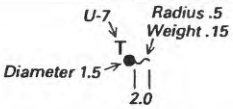
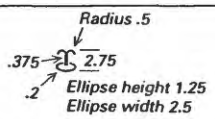
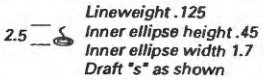
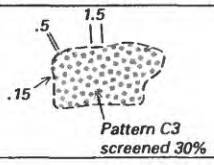
Codes for labels:

611 0020 Label A, active or recently active earthflow or landslide
611 0022 Label D, dormant earthflow or landslide
611 0024 Label DF, debris flow
611 0026 Label EF, earth flow

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.22.1		**Trace of tension crack—Related to landslide, slump, or mass movement**	Patterned line emphasizes feature; minor cracks may be shown by lines having no decorations		**660 0028**
2.22.2		**Trace of slip surface, landslide, Toreva block, block-slump fault, or landslip fault**	The names of this type of feature have varied greatly from map to map depending on local details. Downhill edge of slip surface covered by debris rarely is shown		**660 0030**
2.22.3		**Landslide scarp—Ticks point downscarp**	Line drawn at top of scarp. Use slip-surface line (above) for trace at head of landslide mass. Symbol is used for the physiographic scarp feature and is not used for the mapped boundary of landslide deposits		**640 0026**
2.22.4		**Landslide toe—Ticks point downslope. Arrows show direction of movement**			**640 0028** Left arrow 611 0060 Right arrow 611 0052
2.22.5		**Boundary of sag, sag pond, or topographic depression on a landslide**	May be shown in brown if brown ink is used		**640 0029**
2.22.6		**Path of gully on landslide**			**640 0030** Arrowhead 611 0140

2.23 VOLCANIC FEATURES

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.23.1		**Rim of volcanic crater**	Ticks point inward. Low point of crater is shown by a dot Rim may not outline crater completely		Rim crest **640 0005**
2.23.2		**Caldera margin—Showing outline of topographic wall**	Ticks point inward. Margin may be approximately located, inferred, or buried by younger deposits (indicate by line pattern) Show different calderas by color or double ticks		**640 0007** Approximate 060 0001 Inferred 060 0002 Concealed 060 0003 If several distinguished 067 000S
2.23.3		**Outline of lava pond**	Basalt-filled depression that is bounded by levees (shown by T-shaped ticks pointing inward)		**640 0010**
2.23.4		**Pressure ridge or tumulus on lava flow—Showing crest line**	Draw on axis of ridge		**640 0012**
2.23.5		**Pressure ridges on lava flows**	Form lines are normal to local flow directions		**640 0014**
2.23.6		**Lava tube**	Line shows position beneath surface, and circles show skylights		Trace **650 0016** Skylight 630 0022
2.23.7		**Cone on surface of lava flow**	Small cone, cinder cone, or spatter cone (hornito) on surface of a lava flow		Cone **630 0020**
2.23.8		**Volcanic fissure—Crosshatched where lava was emitted, dotted where concealed by younger unit**			**640 0017** **640 0018**

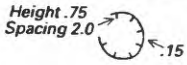
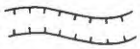
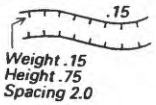
Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.23.9		**Flow lobe**	Boundary drawn at foot of lobe of lava flow, and ticks point away from lobe		**640 0019** 067 000S
2.23.10		**Flow lines on lava flow**	Arrow heads on trace show flow direction		Flow line **640 0025** Arrow heads 611 0140 Rotation 063 0xxx
2.23.11		**Contact separating different lava flows from the same vent or different vents**	Print in red		Different flows, same vent **640 0021** Different flows, different vent **640 0022**
2.23.12		**Cracks on surface of lava flow**	Print in red or black		**640 0023**
2.23.13		**Outline of rootless vent area on lava flow**	Identified by steeply dipping foliation and lineation Print in red		**640 0024**
2.23.14		**Flow direction at base of ash deposits formed in surges**	Identified from antidune bed forms		**600 0066** Rotation 063 0xxx
2.23.15		**Thermal spring**	Drainage line rotated to show flow downhill Use an open circle to show second type		**630 0024** Rotation 063 0xxx
2.23.16		**Geyser**			**630 0026**
2.23.17		**Fumarole or steam vent**			**630 0028**
2.23.18		**Thermal area**	Print in red Pattern C3 on area plus 30 percent screen		**690 0020**

2.24 NEOTECTONIC (EARTHQUAKE HAZARD) FEATURES

Use a lookup table to supply data on the time and magnitude of an earthquake. For an event represented by a point, the approximate location of a point projected to the surface of the Earth may require multiple values from a lookup table.

Use codes and symbols from landslides and mass-wasting features for similar features created by seismic shock.

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.24.1		**Earthquake epicenter Magnitude**	Size of symbol is varied to indicate magnitude Show in red		**617 000T**
2.24.1a		**>7.5**		Diameter 4.5 Diameter 5.75 Weight .275 Diameter 7.0 Weight .275	
2.24.1b		**7–7.49**		Diameter 4.25	
2.24.1c		**6.5–6.99**		Diameter 2.375 Diameter 4.0 Weight .25	
2.24.1d		**6–6.49**		Diameter 2.25	
2.24.1e		**5.5-5.9**		Diameter 2.25 Weight .25	
2.24.1f		**4–5.49**		Diameter 1.4 Weight .2	
2.24.1g		**<4**		Diameter .875 Weight .125	
2.24.2		**Fissures or cracks—Formed in ground by an earthquake**	May be shown in color	.15 Lengths may vary	**640 0142**
2.24.3		**Fissures and sand and (or) other material ejected during an earthquake**	May be shown in color	.2 Lengths may vary	**640 0143**
2.24.4		**Crater or rim crest—Formed by shock or sand blowouts**	May be shown in color	Height .75 Spacing 1.125 .2	**640 0144**

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.24.5		**Crater or sinkhole-hole—Formed by shock**	Too small to show rim at map scale		**600 0080**
2.24.6		**Sunken ground—Showing outer limits of subsidence**			**640 0146**
2.24.7		**Fault scarp—Showing top edge of scarp. Ticks point downscarp**			**640 0140**

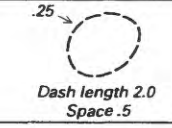
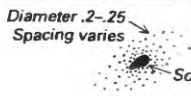
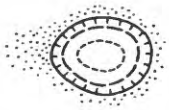
2.25 IMPACT CRATER FEATURES

Additional codes to use with traces:

060 0001 Approximately located
060 0003 Concealed

For recent features, date traces by using major code 0071 and a minor code such as the date of the year (if more information is needed for an impact feature, use a lookup table):

071 aaaa Example: 071 1994

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.25.1		**Impact crater**	Symbol used for a crater too small to outline at map scale		**600 0151**
2.25.2		**Impact crater, primary**			**600 0152**
2.25.3		**Impact crater, secondary—Formed by debris thrown up from primary crater**			**600 0152**
2.25.4		**Impact crater—Without a raised rim**			**640 0151**
2.25.5		**Impact crater—Showing rim**			**640 0152**
2.25.6		**Impact crater—Showing outer boundary of floor**			**640 0154**
2.25.7		**Complex impact crater—Showing outer boundary of central mound**			**640 0156**
2.25.8		**Palimpsest area**	Map as an ejecta unit if thick rather than as a palimpsest area		**690 0098**
2.25.9		**Palimpsest area around impact feature—Morphology of area surrounding crater obscured by ejecta**	Symbol is composite of 2.25.4, 2.25.6, 2.25.7, and 2.25.8, as applicable		**640 0152** 640 0154 640 0156 690 0098

2.26 PALEONTOLOGY

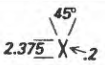
2.26.1 FOSSIL LOCALITY SYMBOLS

In the interest of preserving fossils resources, land management agencies at all jurisdictional levels and private land owners may not want specific fossil localities identified on published geologic maps. The author of a geologic map is responsible for ascertaining the policy of the agency or private party regarding publication of locality information, as well as for obtaining permission before publication to show a collection locality on a map.

The collection accession number is assigned if a collection has a formal collection number in the catalog of the institution or organization responsible for preserving the fossils and, as necessary, if permission has been obtained from the land management agency to show the collection locality.

Code for locality

607 000T	Locality	T denotes lookup table number
071 nnnn	Collection accession number	nnnn denotes accession number from lookup table

2.26.1	◈ D4426	**Fossil locality—Showing collection accession number**		Symbol **607 000T** Accession number 071 nnnn
2.26.2	X	**Fossil locality—Fossils not accessioned**		**607 000T**

2.26.3 FOSSIL SYMBOLS FOR STRATIGRAPHIC COLUMNS

Draft or reproduce symbols as shown. Fossil symbols are not referenced spatially by geodetic coordinates to a map area.

Reference number	Fossil symbol	Fossil type
2.26.3		Acritarchs
2.26.4		Algae
2.26.5		Ammonites
2.26.6		Archaeo-cyathids
2.26.7		Belemnites
2.26.8		Bones
2.26.9		Brachiopods
2.26.10		Brackish-water fossils
2.26.11		Bryozoa
2.26.12		Calcareous nannoplankton (coccoliths)
2.26.13		Cephalopods
2.26.14		Charophytes
2.26.15		Chitinozoans
2.26.16		Conodonts
2.26.17		Corals
2.26.18		Crinoids
2.26.19		Diatoms
2.26.20		Dinoflagellates
2.26.21		Echinoderms
2.26.22		Echinoids

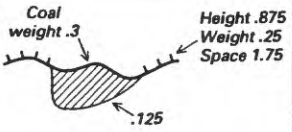
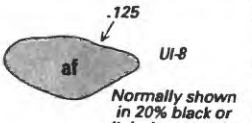
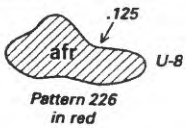
Reference number	Fossil symbol	Fossil type
2.26.23		Fish remains
2.26.24		Fish scales
2.26.25		Foraminifers, in general
2.26.26		Foraminifers, larger
2.26.27		Foraminifers, smaller and benthonic
2.26.28		Foraminifers, smaller and pelagic
2.26.29		Fossils, abundant
2.26.30		Fossils, in general
2.26.31		Fossils, sparse
2.26.32		Fresh-water fossils
2.26.33		Gastropods
2.26.34		Graptolites
2.26.35		Hyoliths
2.26.36		Insects
2.26.37		Lamellibranchs (pelecypods)
2.26.38		Leaves
2.26.39	M	Marine fossils
2.26.40		Microfossils, calcareous
2.26.41	*	Microfossils, in general

Reference number	Fossil symbol	Fossil type
2.26.42		Needles
2.26.43		Oncolites
2.26.44		Ostracods
2.26.45		Plant remains
2.26.46		Pollen and (or) spores
2.26.47		Radiolaria
2.26.48		Roots
2.26.49		Rostroconchs
2.26.50		Rudists
2.26.51		Silicoflagel-lates and (or) ebridians
2.26.52		Spicules
2.26.53		Sponges
2.26.54		Sporomorphs
2.26.55		Stromatolites
2.26.56		Stromatop-oroids
2.26.57		Teeth
2.26.58		Trace fossils
2.26.59		Trilobites
2.26.60		Vertebrates
2.26.61		Wood

NATURAL RESOURCES

2.27 AREAS OF EXTENSIVELY DISTURBED GROUND

Areas of extensively disturbed ground are generally overlays on the geologic unit for the area.

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.27.1		**Graded area—Extensive amount of mapped geologic unit has been removed**	Red pattern 226 at 45° angle and red boundary		**690 0106**
2.27.2		**Strip mine**	Pattern where mined commodity, such as coal, is stripped. Black pattern 226 and black boundary. Ticks point toward stripped area		**690 0108**
2.27.3		**Artificial fill—Earth materials**	Normally fill with a light gray tint (example: 212, 20% yellow, 10% magenta, and 20% cyan). Black boundary May be shown as separate geologic unit		**690 0100**
2.27.4		**Artificial fill—Human generated refuse (landfill)**	Red pattern 226 at 45° angle and gray overprint. Black boundary May be shown as separate geologic unit		**690 0101**

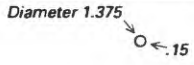
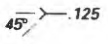
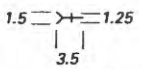
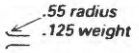
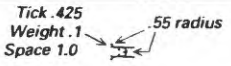
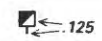
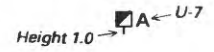
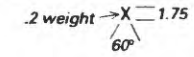
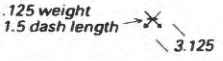
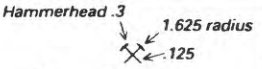
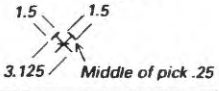
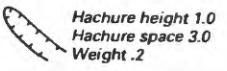
2.28 AREAS OF WORKINGS AS MAPPED UNITS

Cuts and mine workings are overprints on the geologic unit for the area.

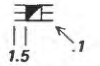
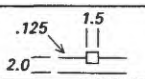
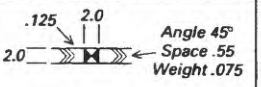
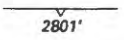
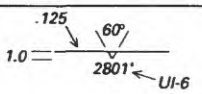
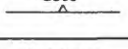
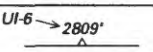
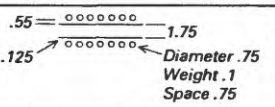
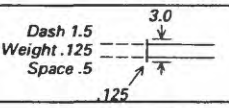
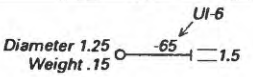
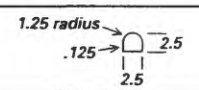
Tailings (pond) and mine dumps replace rock units for the areas that they cover.

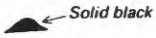
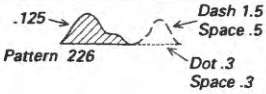
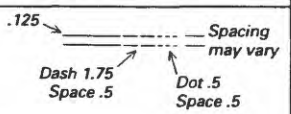
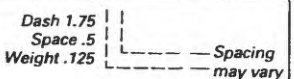
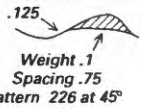
2.28.1		**Open cut or open pit mine, quarry, or glory hole**	Line drawn to scale at top of cut; ticks point into working Symbol 2.29.11 or 2.29.13 may be added to emphasize mine		**690 0114** 630 0110
2.28.2		**Subsurface workings—Projected to surface**	Explain in explanation of map Show in red		**690 0116**
2.28.3		**Tailings, including tailings pond**	Show as a geologic unit		**690 0102**
2.28.4		**Mine dump**	Show as a geologic unit		**690 0104**

2.29 MINING AND MINERAL EXPLORATION

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.29.1		**Drill hole for mineral exploration**			**600 0200**
2.29.2		**Inclined adit—Having a tunnel entry**	Orientation indicates azimuth of adit. Intersection of lines forming symbol is placed at map position of adit		Adit **620 0100** Rotation 063 0xxx
2.29.3		**Inclined adit—Inaccessible**			Inaccessible adit **620 0102**
2.29.4		**Portal**			**630 0103**
2.29.5		**Portal and open cut**			**630 0107**
2.29.6		**Vertical mine shaft**			Shaft **630 0100**
		**Multiple shafts**			
2.29.7		**Vertical mine shaft—Abandoned or inaccessible**			Inaccessible shaft **630 0101**
2.29.8		**Inclined mine shaft**	Orientation indicates location of entry at surface		Inclined **620 0114** Rotation 063 0xxx
2.29.9		**Inclined mine shaft—Abandoned or inaccessible**			Inaccessible shaft **620 0115**
2.29.10		**Prospect (pit or small open cut)**			**630 0102**
2.29.11		**Sand, gravel, clay, or placer pit**			**630 0104**
2.29.12		**Sand, gravel, clay, or placer pit—Abandoned**			**630 0106**
2.29.13		**Open pit, quarry, or glory hole**			**630 0110**
2.29.14		**Open pit, quarry, or glory hole—Abandoned**			**630 0112**
2.29.15		**Trench**	Length of bar between > < ends may be extended if required in order to represent full length of trench; bar follows direction of trench		Trench symbol **620 0104** Rotation 063 0xxx
2.29.16		**Trench—Drawn to scale**			Trench drawn to scale 640 0113

2.30 MAPS OF MINES AND UNDERGROUND WORKINGS

Reference Number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.30.1		Mine shaft—Above and below level			No coding assigned
2.30.2		Inclined mine shaft—Above and below level			No coding assigned
2.30.3		Bottom of mine shaft			No coding assigned
2.30.4		Winze or head of raise			No coding assigned
2.30.5		Raise or foot of winze			No coding assigned
2.30.6		Raise or winze extending through level			No coding assigned
2.30.7		Ore chute			No coding assigned
2.30.8		Inclined workings—Above and below level. Chevrons point down incline			No coding assigned
2.30.9		Stope	Different patterns may be used to indicate type of rock or ore removed		No coding assigned
2.30.10		Elevation of roof or back			No coding assigned
2.30.11		Elevation of floor or sill			No coding assigned
2.30.12		Lagging or cribbing along drift			No coding assigned
2.30.13		Caved or otherwise inaccessible workings			No coding assigned
2.30.14		Diamond drill hole—Showing inclination. Negative angles show downward slope			No coding assigned
2.30.15		Crosscut tunnel			No coding assigned

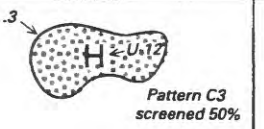
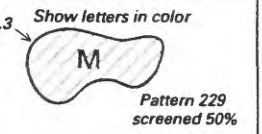
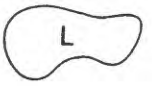
Reference Number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.30.16		**Rubble**			No coding assigned
2.30.17		**Stoped area—Dashed where inferred**			No coding assigned
2.30.18		**Backfilled stope**			No coding assigned
2.30.19		**Mine tunnel and workings**	Use dashed or dotted lines to show sources of information of varying reliability; give source in map explanation		No coding assigned
2.30.20		**Shaft and tunnel—Near line of section (projected to section)**			No coding assigned
2.30.21		**Mine dump—Section view**			No coding assigned

2.31 MINERAL RESOURCE AREAS

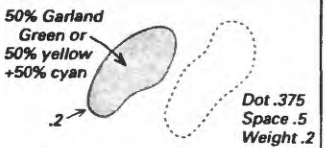
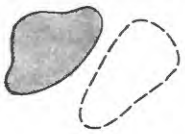
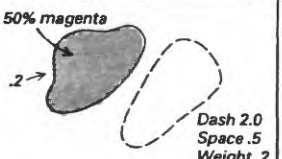
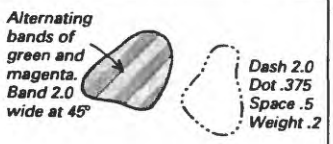
Areas of identified resources and resource potential are shown mostly on special-purpose maps, not on general-purpose geologic maps.

Ratings of certainty of mineral resource potential may be shown for the overprint pattern by the following codes:

060 0006 Available data not adequate
060 0007 Data establish geologic environment and suggest level of resource potential
060 0008 Data establish geologic environment and level of potential but do not establish activity of resource-forming processes
060 0009 Data establish geologic environment and level of potential, as well as indicate activity of resource-forming processes in all or part of area

Reference Number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.31.1		**Identified resources—Showing area**	Show outline in red		Identified resources **690 0200** Commodities 699 000T Color 071 000N
2.31.2		**High mineral resource potential—Showing area**	Outline in red; screened red overprint		High potential **690 0201** Commodities 699 000T Color 071 000N
2.31.3		**Moderate mineral resource potential—Showing area**	Outline in red; screened red overprint		Moderate potential **690 0202** Commodities 699 000T Color 071 000N
2.31.4		**Low mineral resource potential—Showing area**	Outline in red; no overprint		Low potential **690 0203** Commodities 699 000T Color 071 000N
2.31.5		**Mineral resource potential not evaluated—Showing area**	Resource potential considered present but not evaluated, mostly because of inadequate data Show in red; no overprint		Not evaluated **690 0204** 060 0006

2.32 OIL AND GAS FIELDS

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.32.1		**Oil field—Dotted where field extent is not yet defined**	Show outline in green		**690 0222**
2.32.2		**Gas field—Dashed where field extent is not yet defined**	Show outline in red		**690 0224**
2.32.3		**Oil and gas field—Dashed and dotted where field extent is not yet defined**	Show outline in black		**690 0226**

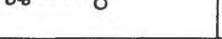
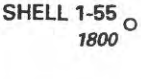
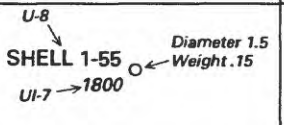
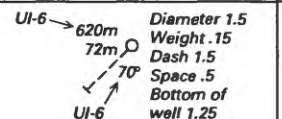
2.33 WELLS DRILLED FOR HYDROCARBON EXPLORATION OR EXPLOITATION

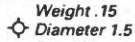
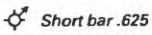
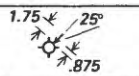
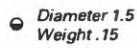
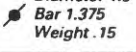
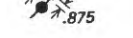
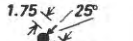
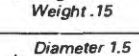
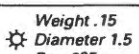
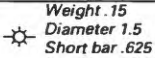
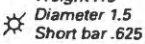
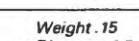
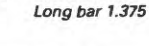
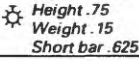
Symbols above for oil and gas wells are used commonly on geologic maps. Additional types are shown on the next pages. The commodity specified is the principal commodity produced. The dry hole symbol is used for unsuccessful holes drilled during hydrocarbon exploration.

On general-purpose maps, show in black.

On energy maps, show water wells in blue, oil wells in green, and gas wells in red.

These symbols, distinguished by type of well, are used commonly on special-purpose energy maps.

2.33.1		**Drilling well (hydrocarbon exploration)**		**600 0220** 060 0220
2.33.2		**Drill hole—No geologic data**		**600 0220**
2.33.3		**Drill hole—Showing operator number and total depth (in feet)**		**600 0220** 699 000T 071 ffff
2.33.4		**Drill hole, inclined—Showing bearing, inclination, collar altitude, and total depth**		**600 0220** 699 000T 071 ffff

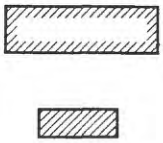
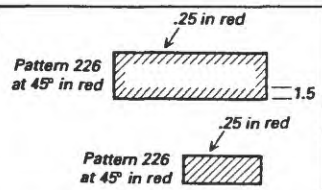
Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.33.5		**Dry hole**	Hole drilled for hydrocarbon exploration	 *Weight .15 Diameter 1.5 Bar .625*	Drill hole **600 0220** Dry 060 0200
2.33.6		**Dry hole converted to water well**		 *Short bar .625*	**600 0220** 060 0213 060 0200
2.33.7		**Dry hole converted to injection well**		 *1.75 25° .875*	**600 0220** 060 0212
2.33.8		**Show of oil**		 *Diameter 1.5 Weight .15*	**600 0220** 060 0207
2.33.9		**Oil well**	Oil is principal or sole commodity produced	 *Diameter 1.5*	**600 0222**
2.33.10		**Shut-in oil well**			**600 0222** 060 0205
2.33.11		**Abandoned oil well**		 *Diameter 1.5 Bar 1.375 Weight .15*	**600 0222** 060 0202
2.33.12		**Abandoned oil well—Converted to water well**		 *1.75 25° .875*	**600 0222** 060 0210
2.33.13		**Abandoned oil well—Converted to injection well**		 *1.75 25° .875*	**600 0222** 060 0212
2.33.14		**Capped oil well**		*Top of T .875 Height .75 Weight .15*	**600 0222** 060 0204
2.33.15		**Show of gas**		 *Diameter 1.5 Weight .15 Short bar .625*	**600 0220** 060 0208
2.33.16		**Gas well**		 *Weight .15 Diameter 1.5 Bar .625*	**600 0224**
2.33.17		**Shut-in gas well**		 *Weight .15 Diameter 1.5 Short bar .625 Long bar 1.375*	**600 0224** 060 0205
2.33.18		**Abandoned gas well**		 *Weight .15 Diameter 1.5 Short bar .625 Long bar 1.375*	**600 0224** 060 0202
2.33.19		**Abandoned gas well—Converted to water well**			**600 0224 060 0212**
2.33.20		**Abandoned gas well—Converted to injection well**		 *Weight .15 Diameter 1.5 Short bar .625 Long bar 1.375*	**600 0224** 060 0210
2.33.21		**Capped gas well**		 *Top of T .875 Height .75 Weight .15 Short bar .625*	**600 0224** 060 0204
2.33.22		**Show of oil and gas**			**600 0220** 060 0209
2.33.23		**Oil and gas well**			**600 0226**

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.33.24		Shut-in oil and gas well			**600 0226** 060 0205
2.33.25		Abandoned oil and gas well			**600 0226** 060 0202
2.33.26		Abandoned oil and gas well—Converted to water well		1.75, 25°, .875	**600 0226** 060 0210
2.33.27		Abandoned oil and gas well—Converted to injection well		Weight .15 Diameter 1.5 Short bar .625 Long bar 1.375	**600 0226** 060 0212
2.33.28		Capped oil and gas well			**600 0226** 060 0204
2.33.29		Abandoned well—Converted to water well			**600 0220** 060 0210
2.33.30		Abandoned well—Converted to injection well		1.75, 25°, .875 Diameter 1.5 Weight .15 Bar 1.375	**600 0220** 060 0213
2.33.31		Saltwater-disposal well		60° 2.75 Diameter 1.25 Weight .125	**600 0220** 060 0215
2.33.32		Water-injection well		Outer diameter 1.5 Weight .15 Inner diameter .375	**600 0220** 060 0213
2.33.33		Water-input well		90° Diameter 1.5 Weight .15	**600 0220** 060 0214

2.34 HAZARDOUS-WASTE SITES

The size of the symbols may vary according to the compiler's preference. If only one or two symbols appear on a map, the compiler may want to make them larger than they would be if more symbols were present. If possible, show hazardous-waste sites in red.

2.34.1		Hazardous-waste site	2.375 60°	**630 0240**
2.34.2		Hazardous-waste site—Showing direction of surface-leachate flow from site	1.25 1.125 25° 2.0	**630 0240** 060 0351
2.34.3		Active (operating) hazardous-waste site		**630 0240** 060 0352

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.34.4		**Inactive (closed) hazardous-waste site**			**630 0240** 060 0353
2.34.5		**Hazardous-waste site—Clean-up activities are in progress**			**630 0240** 060 0354
2.34.6		**Hazardous-waste site—Clean-up activities have been completed**			**630 0240** 060 0355
2.34.7		**Hazardous-waste site—Showing restricted area**			

2.35 GEOLOGIC UNIT LABELS AND SPECIAL CHARACTERS DESIGNATING AGE

2.35.1 UNIT LABELS

Label symbols designate the geologic unit covering each area on a map. Each mappable unit is assigned an abbreviation of no more than six characters. The first, or the first and second, character is used to indicate the age or age limits of the unit. Additional letters complete the label for each mappable rock unit in the order of stratigraphic hierarchy (by using only one of the following pairs or individual units: series and formation, group and formation, formation, formation and member) and rock or sediment type. Unit labels are applied only to mappable rock or sediment units, not geomorphic entities, although sediment units may be identified in part on their geomorphologic aspect.

2.35.2 SPECIAL CHARACTERS DESIGNATING AGE

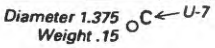
The standard set of special characters designating the age of map units is provided in reference numbers 2.35.2 through 2.35.43 below. Most of the letters and special characters given for the ages are of long-standing use. However, the special characters for the epochs of the Tertiary and for the age subdivisions for the Early and Middle Proterozoic were adopted more recently, and some of these are defined here officially for the first time. Also provided are suggestions for the digital representation in the standard ASCII two-character set. That keyboard character set is suggested for a font 99, one specifically designed for rock-unit labels.

Reference number	Age	Printed map symbol	Recommended font 99, redefined ASCII character
2.35.2	Phanerozoic	PH	33 !
2.35.3	Cenozoic	Cz	35 #
2.35.4	Quaternary	Q	Q
2.35.5	Holocene	H	H
2.35.6	Pleistocene	Ps	36 $
2.35.7	Tertiary	T	T
2.35.8	Neogene	N	N
2.35.9	Pliocene	Po	37 %
2.35.10	Miocene	Mi	38 &
2.35.11	Paleogene	Pg	40 (
2.35.12	Oligocene	Og	41)
2.35.13	Eocene	Eo	42 *
2.35.14	Paleocene	Pa	43 +
2.35.15	Mesozoic	Mz	45 -

Reference number	Age	Printed map symbol	Recommended font 99, redefined ASCII character
2.35.16	Cretaceous	K	K
2.35.17	Jurassic	J	J
2.35.18	Triassic	Ŧ	60 <
2.35.19	Paleozoic	Pz	61 =
2.35.20	Permian	P	P
2.35.21	Carboniferous	C	C
2.35.22	Pennsylvanian	Ꝑ	64 @
2.35.23	Mississippian	M	M
2.35.24	Devonian	D	D
2.35.25	Silurian	S	S
2.35.26	Ordovician	O	O
2.35.27	Cambrian	Ꞓ	91 [
2.35.28	Precambrian	pЄ	p91 p[
2.35.29	Proterozoic	Ꝑ	93]
2.35.30	Late Proterozoic	Z	Z
2.35.31	Middle Proterozoic	Y	Y
2.35.32	Middle Proterozoic 1,200–900 Ma	Y^3	94 ^
2.35.33	Middle Proterozoic 1,400–1,200 Ma	Y^2	95 _
2.35.34	Middle Proterozoic 1,600–1,400 Ma	Y^1	123 {
2.35.35	Early Proterozoic	X	X
2.35.36	Early Proterozoic 1,800–1,600 Ma	X^3	124 |
2.35.37	Early Proterozoic 2,100–1,800 Ma	X^2	125 }
2.35.38	Early Proterozoic 2,500–2,100 Ma	X^1	126 ~
2.35.39	Archean	A	A
2.35.40	Late Archean 3,000–2,500 Ma	W	W
2.35.41	Middle Archean 3,400–3,000 Ma	V	V

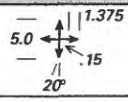
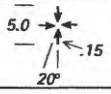
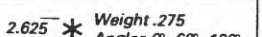
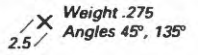
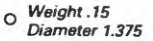
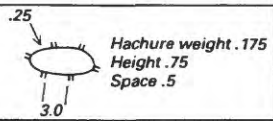
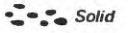
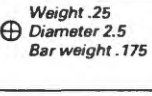
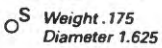
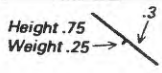
Reference number	Age	Printed map symbol	Recommended font 99, redefined ASCII character
2.35.42	Early Archean 3,800(?)–3,400 Ma	U	U
2.35.43	pre-Archean >3,800 Ma(?)	pA	pA

2.36 MISCELLANEOUS GEOLOGIC FEATURES

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.36.1		**Breccia pipe**			**630 0010**
2.36.2		**Collapse structure—Indicating breccia pipe at depth**			**630 0011**
2.36.3		**Collapse structure or sinkhole**			**630 0012**
2.36.4		**Crater outline—Origin not specified**			**640 0003**
2.36.5		**Biostratigraphic zone—Showing zone boundary**			Lookup table Number for zone **687 000T** 071 000N
2.36.6		**Metamorphic facies—Showing boundary between diagnostic mineral assemblages**	Show in red		Lookup table Number for zone **687 000T** 071 000N

2.37 GEOLOGIC FEATURES RESERVED FOR INTERMEDIATE– AND SMALL–SCALE MAPS

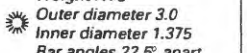
SCALE OF 1:250,000 OR SMALLER

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes	
2.5.26		Dome				630 0040
2.5.27		Basin				630 0041
2.37.1		Active volcano				630 0023
2.37.2		Inactive volcano				630 0025
2.37.3		Cinder cone				630 0027
2.37.4		Diatreme				630 0029
2.37.5		Metamorphic core complex				630 0050
2.37.6		Salt and (or) shale diapirs	Specify type(s) in map explanation			630 0055
2.37.7		Uplift—Local, intensely disturbed				630 0056
2.37.8		Salt dome				630 0057
2.37.9		Possible salt dome				630 0058
2.37.10		Normal fault—Tick to label downthrown side				630 0032
2.37.11		Graben				630 0033
2.37.12		Reverse fault—R on upthrown block				630 0034

2.38 GEOLOGIC FEATURES RESERVED FOR SMALL–SCALE MAPS

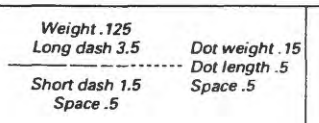
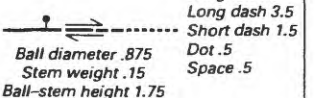
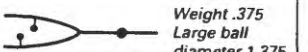
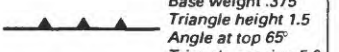
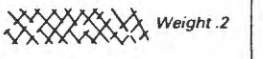
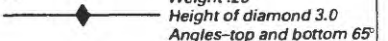
SCALE OF 1:500,000 OR SMALLER

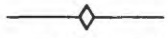
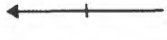
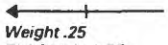
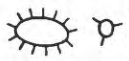
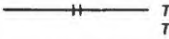
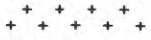
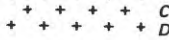
Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.38.1		Midoceanic ridge— Axis without a rift		Weight .625	640 0060
2.38.2		Midoceanic ridge—Axis with a rift		Weight .175 Space .55	640 0061
2.38.3		Deep seismofocal zone—Showing surface trace		Radius 3.0 1.25 .375 6.25	640 0063
2.38.4		Continental slope—Showing margin		Height .875 Width 1.5 6.25 .3 .125 2.25 Pattern 132	640 0065
2.38.5		Ancient spreading axis		2.5 60° 1.25 10.0 Weight .225 Space .75	640 0067
2.38.6		Transform fault—Ticks indicate downthrown side, and arrows show direction of movement		1.75 Weight .15 .375 25° Space .5 5.0 Hachure 1.0 Weight .075 Space .375	640 0068
2.38.7		Basin outline—Triangles point inward		Height 1.25 Weight .2 Spacing 6.25 60°	640 0069
2.38.8		Deep-sea trench—Showing margin. Patterned where filled by sedimentation		Weight .2 Pattern 119	640 0180
2.38.9		Oceanic rise—Showing margin		4.5 Weight .175 Height 1.0 Space .625 .175	640 0182
2.38.10		Volcanic ridge or major volcanic edifice—Label indicates age or end of volcanism		Weight .2 Height .625 Space 2.25 .2	640 0186
2.38.11		Guyot		Weight .2 Height .625 Space .5	Symbol 630 0059 Outline to scale 640 0077
2.38.12		Seamount—Solid triangles indicate volcanic origin		5.0 60° Weight .2 Height 1.0	630 0060

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.38.13		**Seamount—Too small to outline at map scale. Solid fill indicates volcanic origin**			**630 0062**
2.38.14		**Recent volcano**			**630 0070**

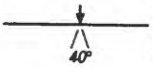
2.39 SELECTED PLANETARY GEOLOGIC SYMBOLS

Composite planetary geologic symbols should be described in the map explanation.

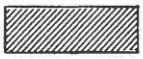
2.39.1		**Contact—Dashed where approximately located, short dashed where inferred, dotted where concealed**			**669 0001** Approximate 060 0001 Inferred 060 0002 Concealed 063 0003
2.39.2		**Fault—Bar and ball on downthrown side, arrows show relative direction of movement. Dashed where approximately located, short dashed where inferred, dotted where concealed**			**669 0010** Bar and ball 611 0056 Approximate 060 0001 Inferred 060 0002 Concealed 060 0003
2.39.3		**Graben**	Shown by a single line where bounding faults cannot be mapped separately		**669 0033**
2.39.4		**Thrust fault or ramp—Sawteeth on upper plate**			**669 0010**
2.39.5		**Lineament**			**669 0100**
2.39.6		**Joint or fracture pattern**			**669 0014**
2.39.7		**Ridge crest, type 1**	May be shown in red		No coding assigned

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.39.8		**Ridge crest, type 2**		 *Weight of diamond .275*	No coding assigned
2.39.9		**Long ridge crest—Abrupt termination shown at point of arrow or gradual termination**		 *Weight .25 Tick height 1.75 Arrow length 1.375 Arrow angle at point 65°*	No coding assigned
2.39.10		**Scarp base—Barbs point downslope**		 *Weight .25 Triangle height 1.5 Angle at bottom 65°*	No coding assigned
2.39.11		**Scarp top—Hachures point downslope**		*Weight .25 Hachure weight .2 Hachure height 1.0 Hachure space 5.0*	No coding assigned
2.39.12		**Lobate scarp—Hachures at top of scarp point downslope**		*Weight .25 Hachure height 1.0 Hachure space 2.0*	No coding assigned
2.39.13		**Basal scarp—Hachures at top of scarp point downslope**		 *Weight .25 Hachure weight .2 Hachure height 1.25 Hachure space 3.0*	No coding assigned
2.39.14		**Dome or circular scarp—Hachures point downslope**		 *Outline weight .25 Hachure weight .2 Hachure height 1.25 Hachure space 1.25*	No coding assigned
2.39.15		**Depression**		 *Outline weight .25 Hachure weight .2 Hachure height .875 Hachure space 3.5*	No coding assigned
2.39.16		**Trough or narrow depression**		 *Weight .25 Triangle height 1.5 Base and top angles 65°*	No coding assigned
2.39.17		**Shallow linear depression, narrow valley, or channel**	Normally shown in blue	*Weight .25 Dash 4.0 Dot .375 Space .375*	No coding assigned
2.39.18		**Furrow**		 *Weight .25 Sides of square 1.75*	No coding assigned
2.39.19		**Sharp groove**	May be shown in red	 *Weight .25 Tick height 1.5 Tick spacing .825*	No coding assigned
2.39.20		**Subdued groove**		 *Weight .25 Tick height 1.5*	No coding assigned
2.39.21		**Reticulate grooves—Showing trend**	Pattern 327	 *Weight .15 Crossbar length 1.125 Diagonal spacing 3.0*	No coding assigned

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.39.22		**Crater rim—Showing crest**		*Spacing of tick sets may vary from 3.0 to 6.25*  *Outline weight .25 Tick weight .2 Tick height .75 Tick space .375*	No coding assigned
2.39.23		**Buried crater rim—Showing crest**		 *Outline weight .25 Dot diameter .25 Dash 4.0 Space .375*	No coding assigned
2.39.24		**Crater—Showing central peak**	Use + if too small to map outline	 *Weight .2 Elliptical width 1.875 Elliptical height 2.625 Bar length 1.5 Crossbar length 2.375*	No coding assigned
2.39.25		**Crater floor—Showing pit. Circle outlines rim**	Use dot if crater is too small to map rim	*Outline weight .2 Solid circle diameter .875*	No coding assigned
2.39.26		**Palimpsest ring**		 *Diameter .875 Space .375*	No coding assigned
2.39.27		**Ejecta—Light-colored**	Pattern 122 in black or red	 *Pattern 122*	No coding assigned
2.39.28		**Ejecta—Dark-colored**	Pattern 7085 in black or red	 *Pattern 7085*	No coding assigned
2.39.29		**Chain craters or collapsed lava tube**		 *Weight .2*	No coding assigned
2.39.30		**Impact crater—Having a raised rim and a visible ejecta blanket**		 *Outline weight .125*	No coding assigned
2.39.31		**Impact crater—Peak at center of mound surrounded by floor, rim crest (hachured), and rough rim ejecta, continuous ejecta, or a field of secondary craters**		 *Outline weight .125*	No coding assigned
2.39.32		**Caldera**		 *Outline weight .25 Hachure weight .2 Hachure height .625 Space .875*	No coding assigned
2.39.33		**Volcano—Queried if origin is conjectural**	Show color within, if appropriate	 *Outline weight .125 U-8*	No coding assigned
2.39.34		**Volcano—Having a summit crater**	Show color within, if appropriate		No coding assigned

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.39.35		**Flow front—Arrow indicates flow direction**		 *Weight .25 Arrow height 1.375 Stem weight .15 Stem height 1.125*	No coding assigned
2.39.36		**Mountain (rugged)—Origin uncertain**		 *Weight .125 Screen 50%*	No coding assigned
2.39.37		**Channel bars—May be erosional or depositional**		 *Weight .125 Screen 30%*	No coding assigned
2.39.38		**Slide (slump) material—Arrow indicates direction of movement**		 *Outline weight .25 Stem weight .2 Stem height 2.5 Arrow angles 60° Arrow side 1.75*	No coding assigned
2.39.39		**Layering in canyon wall**		 *Weight .2 Lengths will vary*	No coding assigned

PATTERNS USED FOR PLANETARY DEPOSITS

2.39.40		**Terrace deposits**		*Pattern C3*	Codes not provided
2.39.41		**Ejecta or mantling material—Dark-colored**		*Pattern 227*	Codes not provided
2.39.42		**Secondary crater field**	Show in red	*Pattern 102*	Codes not provided
2.39.43		**Diffuse highland-lowland boundary scarp**	Show in red with a scratch boundary	*Pattern 134*	Codes not provided

SELECTED HYDROLOGIC FEATURES USED ON GENERAL-PURPOSE GEOLOGIC MAPS

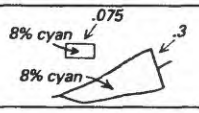
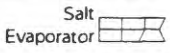
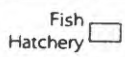
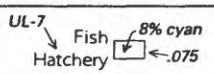
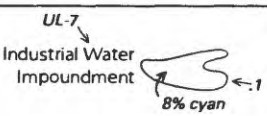
The features and codes listed below were selected from a publication by the U.S. Geological Survey (1989, US GeoData, Digital line graphs from 1:100,000-scale maps: U.S. Geological Survey, National Mapping Program, Technical Instructions, Data Users Guide 2, 88 p.).

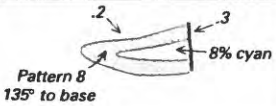
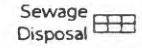
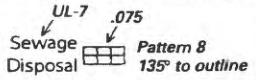
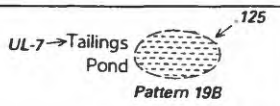
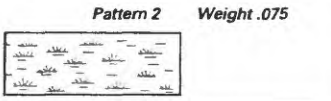
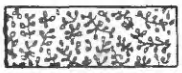
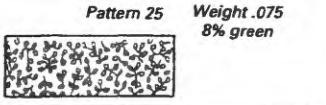
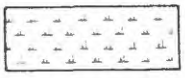
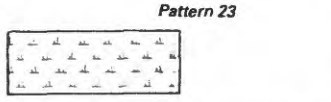
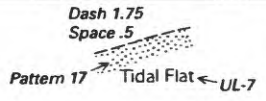
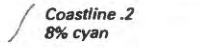
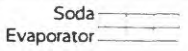
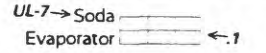
2.40 COMBINED HYDROGRAPHY, FEATURE IDENTIFICATION, POINTS, AND NODES

Codes:

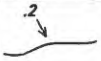
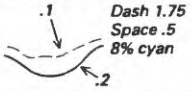
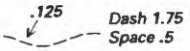
2.40.1	Upper origin of stream	**050 0001**
2.40.2	Upper origin of stream at water body	**050 0002**
2.40.3	Sink channel no longer evident	**050 0003**
2.40.4	Stream entering water body	**050 0004**
2.40.5	Stream exiting water body	**050 0005**

2.41 COMBINED HYDROGRAPHY, FEATURE IDENTIFICATION, AND AREAS

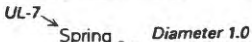
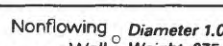
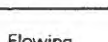
Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.41.1		**Alkali flat**			**050 0100**
2.41.2		**Reservoir**			**050 0101**
2.41.3		**Covered reservoir**			**050 0102**
2.41.4		**Glacier or perma-nent snowfield**			**050 0103**
2.41.5		**Salt evaporator**			**050 0104**
2.41.6		**Inundation area**			**050 0105**
2.41.7		**Fish hatchery or farm**			**050 0106**
2.41.8		**Industrial water impoundment**			**050 0107**

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.41.9		**Area to be submerged**			**050 0108**
2.41.10		**Sewage disposal or filtration pond**			**050 0109**
2.41.11		**Tailings pond**			**050 0110**
2.41.12		**Marsh, wetland, swamp, or bog**			**050 0111**
2.41.13		**Mangrove area**			**050 0112**
2.41.14		**Rice field**			**050 0113**
2.41.15		**Cranberry bog**			**050 0114**
2.41.16		**Flats (tidal, mud, sand, or gravel)**			**050 0115**
2.41.17		**Bay, estuary, gulf, ocean, or sea**			**050 0116**
2.41.18		**Shoal**			**050 0117**
2.41.19		**Soda evaporator**			**050 0118**

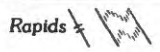
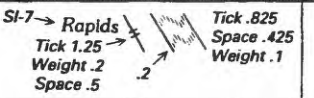
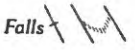
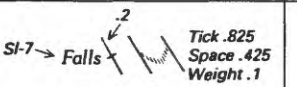
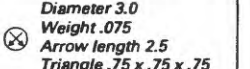
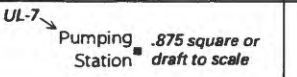
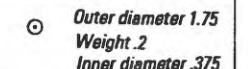
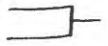
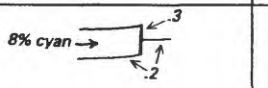
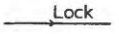
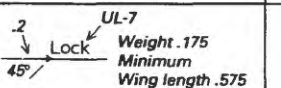
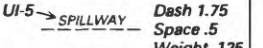
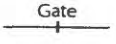
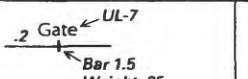
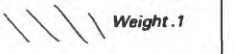
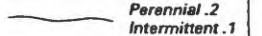
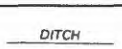
2.42 COMBINED HYDROGRAPHY, FEATURE IDENTIFICATION, AND LINES

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.42.1		**Shoreline**			**050 0200**
2.42.2		**Manmade shoreline**			**050 0201**
2.42.3		**Indefinite shoreline**			**050 0203**
2.42.4		**Apparent limit of water body**			**050 0204**
2.42.5		**Outline of a Carolina bay**			**050 0205**
2.42.6		**Danger curve**			**050 0206**

2.43 COMBINED HYDROGRAPHY, FEATURE IDENTIFICATION, AND POINTS (DEGENERATE LINES)

2.43.1		**Spring**		**050 0300**
2.43.2		**Nonflowing well**		**050 0301**
2.43.3		**Flowing well**		**050 0302**
2.43.4		**Riser**		**050 0303**
2.43.5		**Geyser**		**050 0304**
2.43.6		**Windmill**		**050 0305**

2.44 COMBINED HYDROGRAPHY, FEATURE IDENTIFICATION, AND MULTIPLE ELEMENT TYPES

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.44.1		**Rapids**			**050 0400**
2.44.2		**Falls**			**050 0401**
2.44.3		**Gravel pit or quarry filled with water**			**050 0402**
2.44.4		**Gaging station**			**050 0403**
2.44.5		**Pumping station**			**050 0404**
2.44.6		**Water intake**			**050 0405**
2.44.7		**Dam or weir**			**050 0406**
2.44.8		**Canal lock or sluce gate**			**050 0407**
2.44.9		**Spillway**			**050 0408**
2.44.10		**Gate (flood, tidal, head, or check)**			**050 0409**
2.44.11		**Rock**			**050 0410**
2.44.12		**Crevasse**			**050 0411**
2.44.13		**Stream**			**050 0412**
2.44.14		**Braided stream**			**050 0413**
2.44.15		**Ditch or canal**			**050 0414**

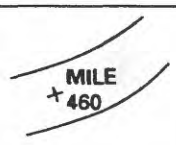
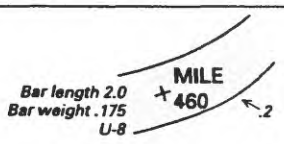
Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.44.16		**Aqueduct**		Perennial .2 Intermittent .1 Spacing may vary	**050 0415**
2.44.17	FLUME	**Flume**		UI-5 → FLUME Dash 1.25 Space .5 Perennial .2 Intermittent .1 Wing length .575 Wing angle 45°	**050 0416**
2.44.18	PENSTOCK	**Penstock**		UI-5 → PENSTOCK Dash 1.25 Space .5 Perennial .2 Intermittent .1 Wing length .575 Wing angle 45°	**050 0417**
2.44.19	SIPHON	**Siphon**		UI-5 → SIPHON Dash 2.5 Space .5 Perennial .2 Intermittent .1	**050 0418**
2.44.20	CHANNEL	**Channel in water area**		UI-5 → CHANNEL Dash 2.5 Space .5 Perennial .2 Intermittent .1 Spacing may vary	**050 0419**
2.44.21		**Wash or ephemeral drain**		Pattern 17	**050 0420**
2.44.22		**Lake or pond**		Weight .2 8% cyan	**050 0421**
2.44.23		**Coral reef**		Coastline .2 Coral reef .075 Draft as shown	**050 0422**
2.44.24	Sand	**Sand in open water**		UL-7 → Sand Diameter .175 Space .375 May also be shown as pattern 17 and no boundary	**050 0423**
2.44.25	SPOIL AREA	**Spoil area**		SPOIL AREA Dash 2.5 Space .5 Weight .175 U-7	**050 0424**

2.45 COMBINED HYDROGRAPHY, DESCRIPTIVE MULTIPLE ELEMENT TYPES (SELECTED)

2.45.1	Right bank	**Right bank**	Code identifies right bank on channel represented by two lines	Right bank Stem length 5.0 Stem weight .2 Barb length 2.0 Barb angle 25°	**050 0605**
2.45.2	Left bank	**Left bank**	Code identifies left bank on channel represented by two lines	Left bank	**050 0606**
2.45.3	Salt	**Salt**	Code identifies salt bloom on dry surface, or water body or spring with salt water	Salt ← U-7	**050 0608**

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.45.4		**Intermittent**	Code identifies that a stream channel or hydrologic feature, described by an accompanying code, contains water only part of the year	 *Dash length 4.0 Dash weight .2 Space .625 Dot diameter .3*	**050 0610**
2.45.5	SUBMERGED JETTY	**Submerged or sunken**	Code identifies that an object or area described by an accompanying code is submerged	SUBMERGED JETTY *Lineweight .2 Dash length 2.0 Space 1.0*	**050 0612**
2.45.6		**Dry**	Code identifies that a stream channel or hydrologic feature, described by an accompanying code, generally contains no water	 *Pattern 117 Dash 2.0 Space .5 Weight .15*	**050 0614**
2.45.7	Sulfur	**Mineral or hot spring (such as sulfur or alkali)**	Code identifies mineral content of spring	Sulfur ← *U-7*	**050 0615**

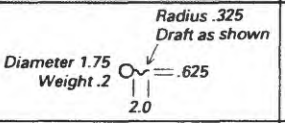
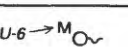
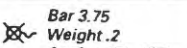
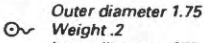
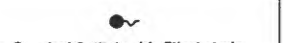
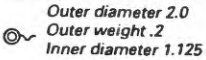
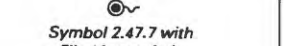
2.46 COMBINED HYDROGRAPHY, PARAMETER, AND MULTIPLE ELEMENT TYPES

2.46.1	*ELEVATION 127*	**Water surface elevation**	Elevation on surface of lake or reservoir	*ELEVATION 127* ← *UI-7*	Elevation in feet **051 ffff** Elevation in meters **052 0mmm** Elevation in feet below datum **056 ffff** Elevation in meters below datum **057 0mmm**
2.46.2	 MILE +460	**River mile**		 *Bar length 2.0 Bar weight .175 U-8* MILE +460 *.2*	**058 mile** Angle of clockwise rotation of + symbol 055 0yyy

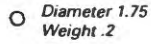
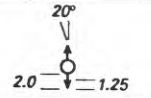
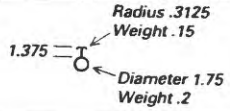
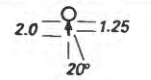
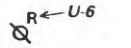
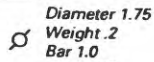
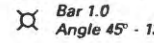
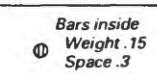
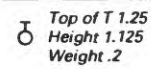
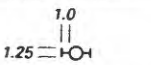
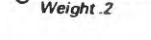
2.47 HYDROLOGIC FEATURES USED ON SPECIAL–PURPOSE HYDROLOGIC MAPS

Generally not recommended for general-purpose geologic maps. However, when identified for the first time in the area of the map, applicable symbols may be used with definitions in the explanation. These symbols are usually shown in color, such as blue, purple, green, red, or black, on the basis of the map theme, color contrast, and clarity.

2.47 SPRINGS OF SPECIFIC TYPES

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.47.1		**Spring**			**630 0024**
2.47.2		**Thermal spring**			**630 0024** 060 0334
2.47.3		**Mineral spring**			**630 0024** 060 0335
2.47.4		**Extinct spring**			**630 0024** 060 0336
2.47.5		**Spring—Used for collection of quality data**			**630 0024** 060 0344
2.47.6		**Spring—Used for domestic water supply**			**630 0024** 060 0320
2.47.7		**Spring—Used for irrigation water supply**			**630 0024** 060 0324
2.47.8		**Spring—Used for industrial water supply**			**630 0024** 060 0326
2.47.9		**Spring—Used for public water supply**			**630 0024** 060 0330
2.47.10		**Unused spring**			**630 0024** 060 0332

2.48 WATER WELLS OF SPECIFIC TYPES

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.48.1		**Water well**			**620 0210**
2.48.2		**Artesian well**			**600 0210** 060 0302
2.48.3		**Nonflowing artesian well**			**600 0210** 060 0301 060 0302
2.48.4		**Water recharge or waste-injection well**			**600 0210** 060 0214
2.48.5		**Observation water well**			**600 0210** 060 0310
2.48.6		**Observation water well—Equipped with recorder**			**600 0210** 060 0311
2.48.7		**Abandoned water well**			**600 0210** 060 0202
2.48.8		**Destroyed water well**			**600 0210** 060 0203
2.48.9		**Test hole for water**			**600 0210** 060 0201
2.48.10		**Water well—Capped**			**600 0210** 060 0204
2.48.11		**Water well—Shut-in**			**600 0210** 060 0205
2.48.12		**Dry hole—Water exploration**			**600 0210** 060 0200
2.48.13		**Well—Used for collection of data**			**600 0210** 060 0312
2.48.14		**Well—Used for domestic water supply**			**600 0210** 060 0320
2.48.15		**Well—Used for stock water supply**			**600 0210** 060 0322

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.48.16	◎	**Well—Used for irrigation water supply**		*Outer diameter 2.0 Outer weight .2 Inner diameter 1.125 Inner weight .15*	**600 0210** 060 0324
2.48.17	◉	**Well—Used for industrial water supply**		*Outer diameter 2.0 Weight .2 Inner diameter 1.125*	**600 0210** 060 0326
2.48.18	○	**Well—Used for public water supply**		*Diameter 2.0 Weight .375*	**600 0210** 060 0330
2.48.19	⌀	**Water well—Unused**		*Diameter 1.75 Weight .2 Bar 3.75 Angle 45°*	**600 0210** 060 0332

2.49 GAGING STATIONS, WATER

2.49.1	△	**Gaging station**		*60° 2.375 .2*	**630 0230**
2.49.2		**Gaging station—Equipped with a telephone or radio**		*Weight .15 Length 1.5 1.25 Length .875*	**630 0230** 060 0340
2.49.3		**Peak-flow measurement station**		*25° 2.0 1.25 Stem weight .125*	**630 0230** 060 0341
2.49.4		**Low-flow measurement station**			**630 0230** 060 0342
2.49.5		**Stage-measurement station**		*25° 2.375 .875 Stem weight .125*	**630 0230** 060 0343
2.49.6		**Gaging station—Used for collection of water-quality data**		*60° 2.375 1.125 Bar length .75 Weight .2*	**630 0230** 060 0344
2.49.7	▲	**Gaging station—Continuous-record**		▲ *Symbol 2.49.1, filled center*	**630 0230** 060 0345

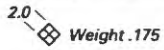
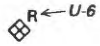
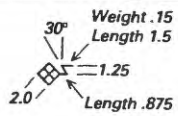
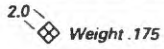
Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.49.8		**Gaging station—Partial-record**		Weight .15; 2.375; 1.2	**630 0230** 060 0346
2.49.9		**Measurement station without a gage**			**630 0230** 060 0347
2.49.10		**Discontinued gaging station**		Bar 3.75; Weight .2	**630 0230** 060 0348

2.50 MISCELLANEOUS HYDROLOGIC SYMBOLS

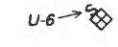
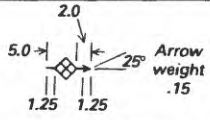
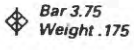
Symbols may be shown in black or blue.

2.50.1		**Surface-water basin boundary**	Weight .6; Dash 7.5; Dot diameter .625; Space .5	Coding not provided
2.50.2		**Surface-water subbasin boundary**	Weight .425; Dash 5.0; Dot diameter .45; Space .5	Coding not provided
2.50.3		**Ground-water divide**	Dot diameter .675; Space .575	Coding not provided
2.50.4		**Ground-water divide—Approximately located**	Dot diameter .7; .2; Space .625; Dash 6.5; Space .5	Coding not provided
2.50.5		**Infiltration gallery**	1.75; .125; 1.125; .625	Coding not provided
2.50.6		**Direction of ground-water flow**	.15; 1.125; 5.75; 30°; 2.125	Coding not provided
2.50.7		**Direction of ground-water flow—Approximate**	6.75; Weight .25; 25°; Arrow-1/2 fill; Dash 1.5; Space .5; 2.75	Coding not provided

2.51 WEATHER STATIONS

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.51.1		**Weather station**	Basic shape centered over site		Coding not provided
2.51.2		**Weather station—Equipped with a recorder**			Coding not provided
2.51.3		**Weather station—Equipped with a telephone or radio**			Coding not provided
2.51.4		**Weather station—Complete**			Coding not provided
2.51.5		**Snow survey course**			Coding not provided

WEATHER STATIONS WHERE DESIGNATED TYPES OF MEASUREMENTS ARE OBTAINED

2.51.6		**Precipitation**			Coding not provided
2.51.7		**Evaporation**			Coding not provided
2.51.8		**Temperature**			Coding not provided
2.51.9		**Humidity**			Coding not provided
2.51.10		**Solar radiation**			Coding not provided
2.51.11		**Wind velocity**			Coding not provided
2.51.12		**Weather station—Discontinued**			Coding not provided

SELECTED TOPOGRAPHIC FEATURES

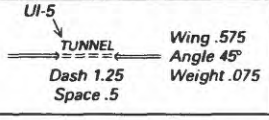
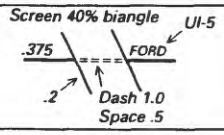
Features shown on the next few pages are commonly part of the topographic base map. Additions may be made as necessary for geologic maps.

Selected codes and features are from a publication by the U.S. Geological Survey (1990, US GeoData, Digital line graphs from 1:24,000-scale maps: U.S. Geological Survey, National Mapping Program, Technical Instructions, Data Users Guide 1, 107 p.).

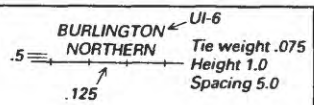
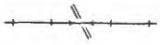
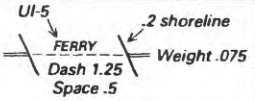
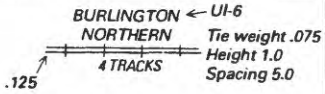
2.52 TRANSPORTATION: ROADS AND TRAILS, FEATURE IDENTIFICATION AND LINES

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.52.1		**Primary route—Class 1, undivided**		*.075–.35–.075, show fill as solid red or 30% black*	**170 0201**
2.52.2		**Primary route—Class 1, divided by centerline**		*.075–.325–.075–.325–.075, show fill as solid red or 30% black*	**170 0202**
2.52.3		**Primary route—Class 1, divided, lanes separated**		*.075–.35–.075–.25–.075–.35–.075, show fill as solid red or 30% black*	**170 0203**
2.52.4		**Secondary route—Class 2, divided, lanes separated**		*.075–.35–.075, fill and space–3.25 Show fill as solid red or 30% black*	**170 0205**
2.52.5		**Road or street—Class 3**		*.375* Screen 40% biangle	**170 0209**
2.52.6		**Road or street—Class 4**		*.175* Screen 40% biangle	**170 0201**
2.52.7	TRAIL	**Trail—Class 5, other than four-wheel-drive vehicles**		*UI-5* TRAIL *Weight .175 Dash 1.25 Space .5*	**170 0211**
2.52.8	JEEP TRAIL	**Trail—Class 5, four-wheel-drive vehicles**		*UI-5* JEEP TRAIL	**170 0212**
2.52.9	70	**Interstate route number**	Two or three digits, flush right	70 *Weight .1 U-6 Draft as shown*	102 0nnn
2.52.10	25	**U.S. route number**	Two or three digits, flush right	25	103 0nnn
2.52.11	36	**State route number**	Two or three digits, flush right	36	104 0nnn

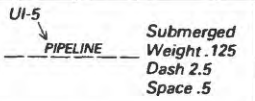
2.53 TRANSPORTATION: ROADS AND TRAILS, DESCRIPTIVE MULTIPLE ELEMENT TYPES

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.53.1		Highway in tunnel			170 0601
2.53.2		Highway overpass on bridge			170 0602
2.53.3		Road submerged or in a ford			170 0606

2.54 TRANSPORTATION: RAILROADS, FEATURE IDENTIFICATION, LINES, AND MULTIPLE ELEMENT TYPES

2.54.1		Railroad			180 0201
2.54.2		Railroad overpass on bridge			180 0602
2.54.3		Ferry crossing			180 0207
2.54.4		Number of tracks			181 0nnn

2.55 TRANSPORTATION: PIPELINES, TRANSMISSION LINES, AND MISCELLANEOUS LINES

2.55.1		Pipeline			190 0201
2.55.2		Power transmission line			190 0202

2.56 BOUNDARIES, FEATURE IDENTIFICATION AND AREAS

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.56.1		**Boundary—Civil township, district, precinct, or barrio**		*Weight .175 Dash 4.25 Space .825*	**090 0100**
2.56.2		**Boundary—Incorporated city, village, town, borough, or hamlet**		*Weight .175 Dash 2.0 and 1.0 Space .5*	**090 0101**
2.56.3		**Boundary—National park, monument, lakeshore, parkway, battlefield, or recreation area**		*Weight .175 Dash 6.25 Space 2.5 Dot diameter .25*	**090 0103**
2.56.4		**Boundary—National forest or grassland**	Symbol same as 2.56.3 Size of letters may vary SM typeface		**090 0104**
2.56.5		**Boundary—National wildlife refuge, game preserve, or fish hatchery**	Symbol same as 2.56.3 Size of letters may vary SM typeface		**090 0105**
2.56.6		**Boundary—National scenic waterway or wilderness area**	Symbol same as 2.56.3 Size of letters may vary SM typeface		**090 0106**
2.56.7		**Boundary—Indian reservation**	Symbol same as 2.56.3 Size of letters may vary SM typeface		**090 0107**
2.56.8		**Boundary—Military reservation**	Symbol same as 2.56.3 Size of letters may vary SM typeface		**090 0108**
2.56.9		**Boundary of Canada**		*Weight .4 Dash 6.25 and 1.75 Space .825*	**090 0197**
2.56.10		**Boundary of Mexico**	Symbol same as 2.56.9 SM typeface	*Weight .4 Dash 6.25 and 1.75 Space .825*	**090 0198**

2.57 BOUNDARIES, FEATURE IDENTIFICATION AND MULTIPLE ELEMENT TYPES

Reference number	Symbol	Description	Notes on usage	Cartographic specifications	Codes
2.57.1	—— – – ——	**State Federal Information Processing Standards (FIPS) code**	Two digits, flush right	—— – – —— *Weight .3 Dash 6.25 and 1.75 Space .825*	091 00nn
2.57.2	—— – —— –	**County or county equivalent FIPS code**	Three digits, flush right	—— – —— – *Weight .25 Dash 6.25 and 1.75 Space .825*	092 0nnn

2.58 HYPSOGRAPHY (SELECTED)

2.58.1	—— ——	**Continental Divide**		—— —— *Weight .3 Dash 10.0 Space 2.5*	290 2017

D R A F T

CARTOGRAPHIC AND DIGITAL STANDARD

FOR GEOLOGIC MAP INFORMATION

PART 3. COLORS AND PATTERNS FOR GEOLOGIC MAPS:

COLOR DESIGN, COLOR AND PATTERN CHARTS

3. COLORS AND PATTERNS FOR GEOLOGIC MAPS: COLOR DESIGN, COLOR AND PATTERN CHARTS

3.1 GUIDELINES FOR COLOR DESIGN OF GEOLOGIC MAPS

3.1.0 INTRODUCTION

Color design is one of the most critical phases of geologic map design because of the significant effect that the use of colors has on map legibility and its ability to communicate information to the map user. The goals in color design are to enhance the legibility of the map and to enhance its meaning by helping to focus the reader's attention on the most important parts of the data.

Color design affects nearly all phases of map production. For maps prepared for colored printing, well designed color treatment can simplify production phases—scribing, if used, lettering, color separation, and printing—and thereby reduce costs. By contrast, careless or incomplete color design can overcomplicate production phases and require many extra hours for preparation, correction, and proofing. For maps prepared for electronic plotter, effective color design will increase the quality and visual clarity of data, may reduce the number of time-consuming test plots needed to achieve an acceptable map presentation, and may reduce the plotter time required to produce a final map and multiple copies of the same map.

Because of its nature, color design requires proper training, including a basic understanding of geology and a background in cartography, in order to be familiar with the kinds of information that earth scientists are trying to express in map format. In addition, color design requires artistic ability—a good eye for color and a grasp of color principles such as balance and contrast.

This section discusses the factors to be considered by authors and color specialists when designing colors for geologic maps. Individual author preferences should not be allowed to supersede established standards and procedures that are widely accepted. Five factors discussed in the following sections are presented in order of their importance: (1) purpose and use of the map, (2) standards for color and pattern selection, (3) color contrast and clarity, (4) coordination with previously published maps, and (5) cost of publication.

3.1.1 FACTORS THAT INFLUENCE GOOD COLOR DESIGN

3.1.1.1 PURPOSE AND USE OF THE MAP

The purpose and use of a map are the overriding considerations in planning color selection.

3.1.1.1.1 Standard Geologic maps. Colors on standard geologic maps, such as U.S. Geological Survey Geologic Quadrangle (GQ) and Miscellaneous Investigations Series (I) maps, should conform closely to colors on the standard color chart established according to age of sedimentary rocks (Section 3.1, p. C-3). Most of the standard map series are now printed using the four process colors: yellow, magenta, cyan, and black.

3.1.1.1.2 Special-use maps. Maps that are designed for specialized use or broad distribution, such as State geologic maps and National or State park maps, may be less limited than standard maps in color design. Colors on special-use maps conform to those established for sedimentary rocks by age, but geologic formations that are of likely special interest to map users may need to be highlighted by special color treatment. The broad appeal of some maps such as park maps, as well as the complexity of some large-format geologic maps, may justify the use of additional color inks to create the array of colors needed to enhance their readability. On maps that cover large areas, tectonic relations may outweigh geologic age when choosing an overall color design.

3.1.1.1.3 Maps utilizing gradational colors. Examples of the appropriate use of gradational color include volcanic-hazards and slope-stability maps. Such maps are printed in more colors than their physical complexity might suggest. On these maps, areas of greatest hazard are shown in red, and they grade through orange to yellow where the hazard is less. Permanent red is preferred over magenta on these maps because it is more brilliant. Examples may be found in publications such as U.S. Geological Survey Miscellaneous Investigations Series Map I-1072 and maps in U.S. Geological Survey Bulletins 1492 and 1503 and in Professional Paper 1204-A. Other kinds of maps properly using gradational color design include those showing phenomena such as humidity, precipitation, and temperature. Gradational colors are applied to geophysical maps to represent magnetic, gravity, and radiometric anomalies and their derivatives.

3.1.1.1.4 Maps showing key beds or key units. Although the color design of geologic maps generally follows the standard sedimentary age color sequence, emphasis may be given to key

units by using special colors. Examples of color design for key units include maps showing coal beds, beds of a minable mineral commodity such as oil shale or gravel, or maps showing the distribution of units with notable geologic engineering properties.

3.1.1.1.5 Hydrologic maps. These maps are commonly printed in two or three colors. These maps show depth to water table by gradational colors ranging from light blue at the shallowest depths to dark blue at the greatest depths. Other maps show concentrations of dissolved solids by using colors ranging from dark blue where concentrations are lowest to dark red where concentrations are highest. Color design for maps of dissolved solids is shown in table 3.1.2.

Table 3.1.1. Example of color design for maps showing dissolved solids

COLOR DESIGN FOR MAPS SHOWING DISSOLVED SOLIDS		
Dissolved solids in milligrams per liter	**Color design—Example 1**	**Color design—Example 2**
0- 50	Dark blue	Dark blue
500- 1,000	Medium blue	Light blue
1,000- 3,000	Light blue	Light blue and light red
3,000-10,000	Light red	Light red
10,000-35,000	Medium red	Medium red
More than 25,000	Dark red	Dark red

3.1.1.2 STANDARDS FOR COLOR AND PATTERN SELECTION

Standards for color and pattern selection have been established by careful design practice and application through the years. The standards are widely accepted and assist in maintaining consistency and continuity of colors and patterns among maps. The sedimentary age color chart on page C-3 is the cornerstone for color design for standard geologic maps; other design elements follow in sequence. Because the geology differs area to area, and because authors have different specialties and needs for emphasis (some scientists take particular care in delineating the various kinds of surficial deposits whereas others lump them together), not all geologic maps fit comfortably into this scheme. For example, a particular map may depict 40 kinds of Tertiary rocks, including a variety of volcanic rocks, and may show no units older than Cretaceous rocks. In this example, some pinks, purples, or other bright colors normally used for rocks of other ages may be required for Tertiary units. Similarly, the same kind of departure from standard color use might be anticipated for a map that shows almost exclusively Precambrian rocks. The key to proper use is that the chosen colors clearly and accurately depict geologic relations. For example, on a map that shows predominantly surficial units, alluvium units may be grouped together in yellow, gravel units in orange, and glacial deposits in blue. A word of caution is advised where colors are "borrowed" from other age color groupings. The designer must be aware of the possibility of conflicts that may arise when using colors from other age groupings that may be present on adjacent maps. An awareness of regional geology and consultations with the author may help guide these choices.

Proper use of patterns can add great diversity to a map, but patterns must be used with great care. The color and pattern charts, pages C-4 through C-37 in this section, illustrate the variety of patterns that can be used. Patterns can be used as overprints in available ink colors, screened a variety of ways, or can be reversed in dark screened and solid areas. Because using patterns increases production costs and because of the potential of patterns for increasing clutter on an already complex map, patterns should only be used on multicolor maps if the complexity of the map requires a greater variety of colors and patterns, or when there is a need to show relations among rock types through the use of patterns. On black-and-white or two-color geologic maps, such as those usually included in book publications, consideration should be given to the cost and complexities involved in the use of patterns. On complex maps, the additional cost of two more printing inks might easily be offset by the cost of the additional peelcoats needed for the patterns and by the amount of cartographic labor involved in cutting and laying patterns and blocking out patterns for type. A multicolor map may be much more legible.

When using patterns, the following guidelines apply:

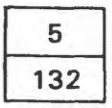
3.1.1.2.1 The type of patterns used should be indicative of the type of rock represented. Although flexibility may be exercised in the use of many different types of patterns, some patterns are by tradition exclusively used for certain rock types. Line patterns should not be used for igneous rocks; and conversely, irregular patterns such as

 or  or 

should not be used for sedimentary rocks.

3.1.1.2.2 In general, base map information and type are more legible under finer patterns that coarser ones; screening patterns when possible eliminates the need to block out the patterns for type. Charts included in this section illustrate patterns that can effectively be screened and to what extent.

On the color and pattern guide provided below, screened patterns are represented as follows:

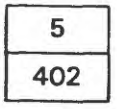


The box indicates that pattern 132 and the 5 screen will be on the same peelcoat and the pattern will be screened 50 percent.

5
132

No box indicates that 132 pattern and 5 screen will be on separate peelcoats; the 132 pattern will print solid on top of a 50 percent tint.

3.1.1.2.3 When screening any pattern, the screen must be at least 30° away from any tint screen in the same color as the pattern. For example:



2

The 402 pattern is screened 50 percent and printed on top of a 20 percent tint. The angle of the 50 percent screen must be 30° away from the angle of the 20 percent tint screen.

3.1.1.2.4 When screening a line pattern, the screen must be at an angle 30° away from the angle of the line.

3.1.1.2.5 If possible, lined or ruled patterns should be angled approximately 90° from the general angle that the formation is running.

This:  Not this: 

3.1.1.3 COLOR CONTRAST AND CLARITY

Contrast among map colors and clarity of map information through the colors significantly impact the overall appearance of the map. An understanding of certain principles of color can make the difference between a visually distracting map that is difficult to read and an attractive, useable map.

Some guiding principles include:

3.1.1.3.1. Light colors are generally preferred for the largest areas on a map and dark colors should be reserved for smaller areas.

3.1.1.3.2. The colors selected for large areas on the map will determine much of the overall appearance of the map. Avoid "muddy" or "gaudy" colors for these areas.

3.1.1.3.3. In the four-color process system, magenta and cyan should not be used in intensities greater than 50 percent, except in very small areas, because base information and other data become illegible.

3.1.1.3.4. Colors have an emotional impact: For example, some colors are thought of as "cool" and other as "hot;" red connotes danger. This principle has

some bearing on color design for geologic maps but even more so on maps with political impact or on maps depicting gradational relations among units.

3.1.1.4 COLOR COORDINATION WITH PREVIOUSLY PUBLISHED MAPS

Map color design must also consider previously published maps adjacent to or near the area of the map being designed. It is desirable to match previously published reports, where possible, particularly if the area is adjacent to, or part of, a block of geologic quadrangles. Matching lends continuity to a study area and makes the maps as a group more legible. Exact matches to previous reports, however, are not always practical. The overriding consideration is legibility. For example, colors on a published map may not provide enough contrast; therefore, to achieve needed contrast on the map being designed, the designer may use colors that approximate those used on the previously published map but may make them darker or lighter as needed. In this way, the map is legible, and the reader can follow the continuity from one map to the next.

When matching previously published maps, designers need to be aware that the color systems have evolved over the years. The earliest color maps used a different printing ink for each age grouping. Later the process system was introduced in which a great variety of colors could be produced with the use of only four printing inks. The first maps produced under this system used Colortrol inks, which are quite different from the process yellow, magenta, cyan, and black currently in use. Not only have ink colors changed, but screen values have changed as

well. Initially, 133-line screens were used in the process color system. Later, the 120-line screens were introduced, and still later, the 120-line screens were remade with slightly different screen percentages. When matching publications older than 1980, color designers should consider the colors as they appear on the published map rather than copying the color number directly from the earlier color guides.

3.1.1.5 COST OF PUBLICATION

Publication cost, although important, should not override legibility, clarity, and usefulness of the map. This principle is important regardless of whether the map is being prepared for release exclusively as a digital file for on-demand reproduction by electronic plotters, or whether the map is being prepared for color printing of a large number of copies. There is no advantage to printing a map that is difficult to read. The skill of the color designer significantly affects costs of materials, man-hours of labor, and printing costs, as evidenced by the following:

3.1.1.5.1 The number of peelcoats should be held to a minimum. Each new screen value introduces a new peelcoat. The introduction of film patterns, hand patterns, or specialized symbols increases the cost of a report by adding complexities that increase production hours. These should therefore be used judiciously. The objective is to maximize map legibility and attractiveness at minimum cost.

3.1.1.5.2 At the present time, many scientific maps are printed on a two-color press. Hence, a two-color map is not much more expensive to print than black-

and-white, but the addition of a third color increases the cost substantially because it increases the number of press runs. However, a sixth ink may be added to a map that requires at least five printing inks without greatly increasing the cost. Careful consideration of the advantages gained by use of another ink must be given when such use requires an additional press run.

3.1.1.5.3 With current technology, maps that are now produced "on demand" by using electronic plotters may each require long periods of time for plotting. Complex colors or patterns add substantially to the plotting time. If a number of maps must be plotted, both the time required with equipment tie-up and the opportunity for malfunction of the plotter and paper-handling equipment may be increased substantially. Advanced planning is required to assess the number of map plots needed, as well as the cost in production and plotting time required for complex color and pattern designs.

3.1.2 TREATMENT OF BASE MAP INFORMATION

The color designer determines the most appropriate way to show base map information. Showing the drainage in blue is preferable on geologic maps because of the relations of the surficial geology to the drainage. On geologic maps, the culture is shown in a denser screened black (normally 40 percent) than the topography (normally 30 percent). Abundant data shown in black, such as structure symbols that would not show up well on screened black topography,

might require use of contour brown for the topography. However, this is the exception rather than the rule because the incorporation of contour brown adds a fifth, and expensive, printing ink. In maps prepared on an electronic plotter, the visibility of contour lines plotted in brown may be reduced or obscured when certain other plotter colors are overprinted.

On some geologic maps, it is not practical or feasible to print the drainage in a separate color. Where compilation has been done on a composite mosaicked base, the number of hours required to reconstruct a color-separated mosaicked base is prohibitive when several images are involved. It is both critical and difficult to re-register author compilation to a new base. In cases such as the special-use maps described above, it may be worthwhile to reconstruct a color-separated mosaicked base despite the difficulties involved. However, advanced planning is best.

Where composite map bases are used, they are normally shown in screened black or in contour brown or burnt sienna. Contour brown or burnt sienna is recommended in the following situations:

3.1.2.1 **Maps at enlarged scales**. For example, on a 1:125,000-scale map enlarged from 1:250,000, base data shown in black would be difficult to read even on a much subdued screened black. Brown or burnt sienna would be legible without obscuring geologic information.

3.1.2.2 **Mosaics that incorporate images at various scales.** For example, consider 1:24,000-scale maps reduced to 1:48,000 and mosaicked together with 1:62,500-scale maps enlarged to 1:48,000. In order to screen the enlarged contours enough to print in black, the reduced contours may be lost.

3.1.2.3 **Combinations that include a water tint.** A moiré pattern is created where tints are screened a second time by using a biangle screen. Such a pattern is unattractive, distracting, and commonly conceals other map information.

Color-separated bases are not required on many types of thematic earth science maps such as simple two-color maps (black and brown, or black and red) that have highly generalized information. Such maps include aeromagnetic maps and other maps showing data only in black, such as point localities or contours. However, these data show up well on a burnt sienna base.

[3.2 COLORS AND PATTERNS, pages C-1 through C-39 follows]

☆U.S. GOVERNMENT PRINTING OFFICE: 1995 - 387-088/34069

Colors and Patterns Commonly Used in U.S. Geological Survey Publications

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PRINTED DECEMBER 1994

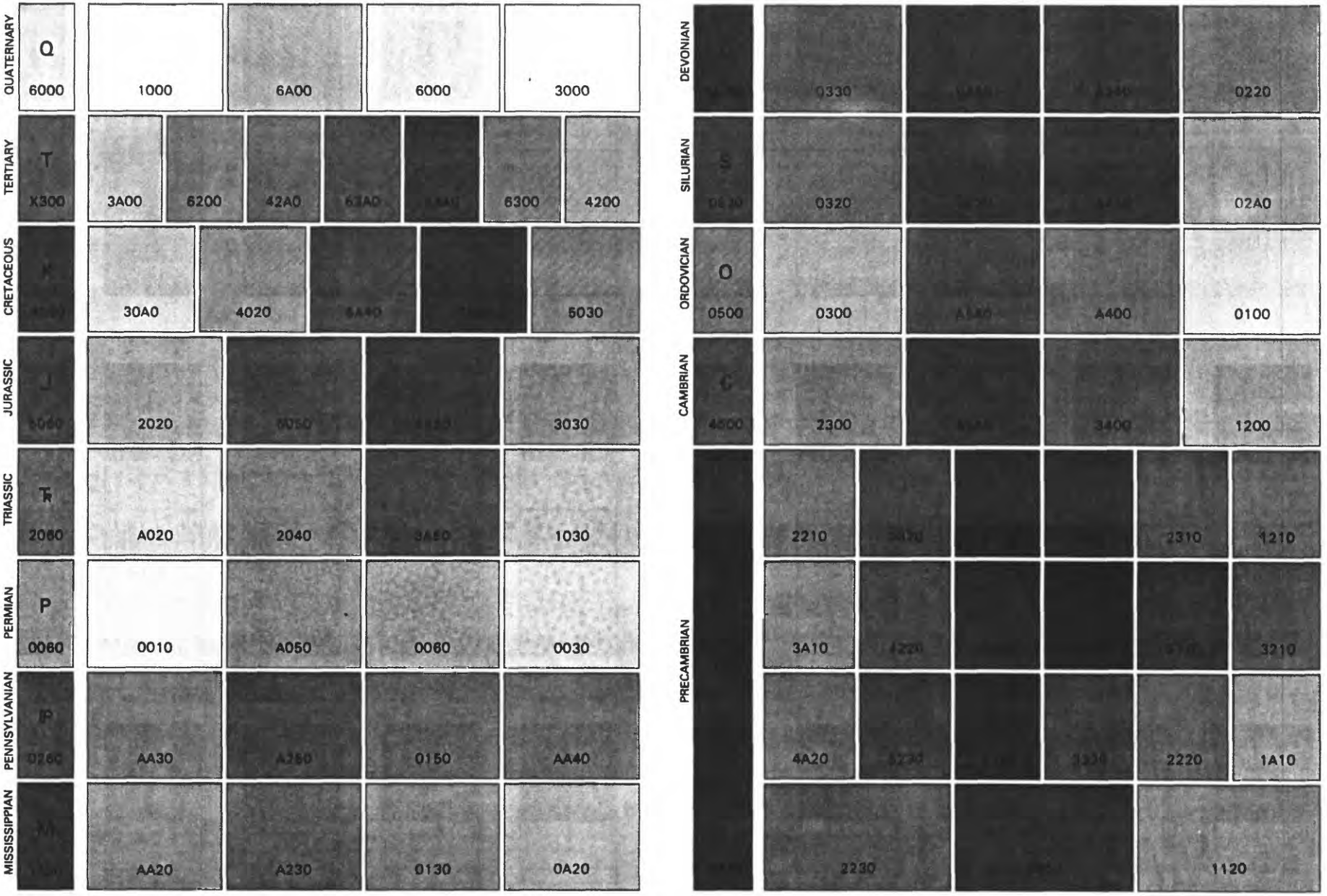
SEDIMENTARY AGE COLORS

U.S. GEOLOGICAL SURVEY

PRINTING INK CODES AND SCREEN PERCENTAGES

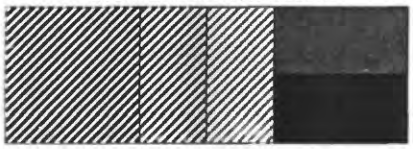
1 2 3 4 5
YELLOW MAGENTA CYAN BLACK RED

A-8%
1-13%
2-20%
3-30%
4-40%
5-50%
6-60%
7-70%
X-100%



VOLCANIC COLORS

SEDIMENTARY PATTERNS



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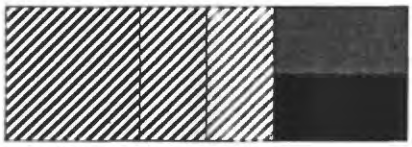

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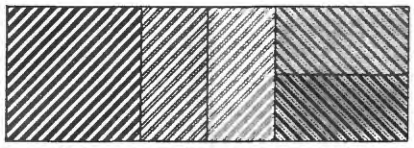

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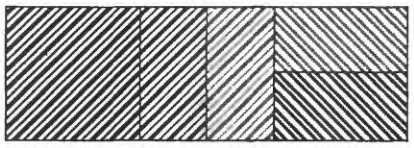

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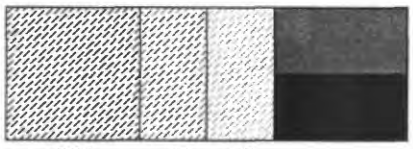

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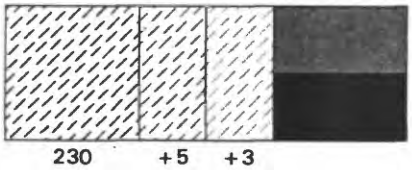

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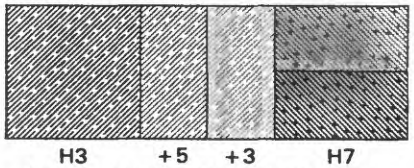

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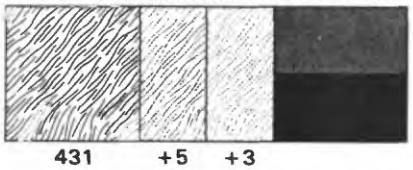

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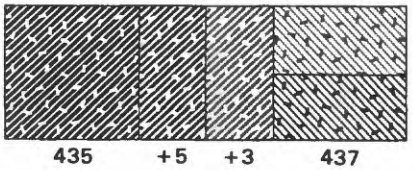

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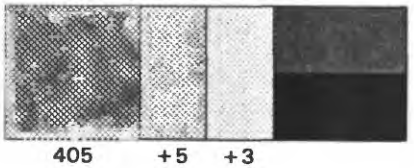

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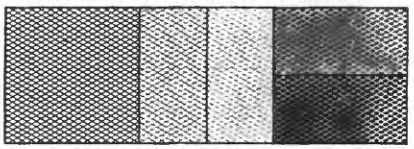

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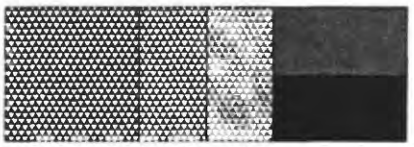

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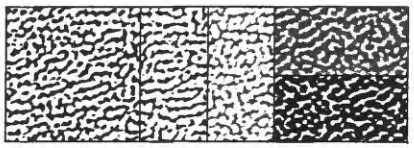

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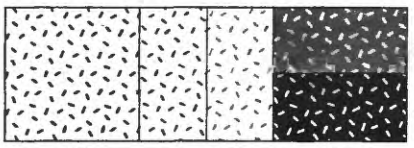

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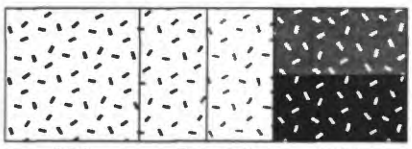

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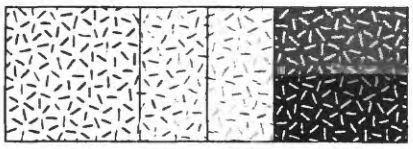

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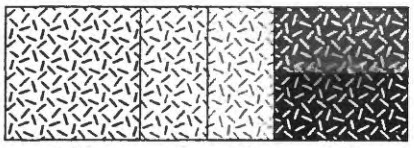

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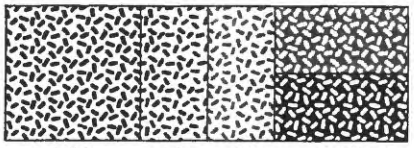

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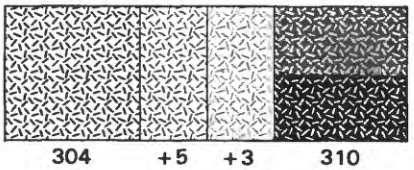

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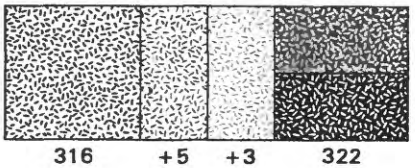

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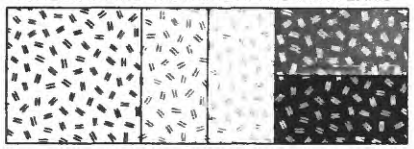

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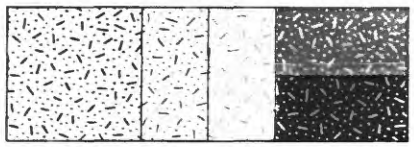

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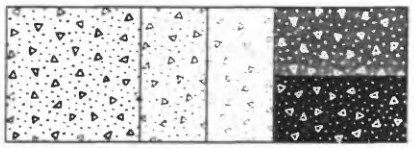

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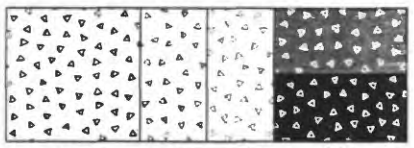

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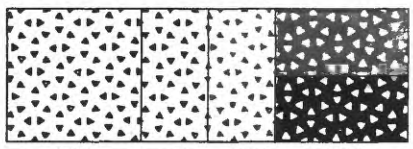

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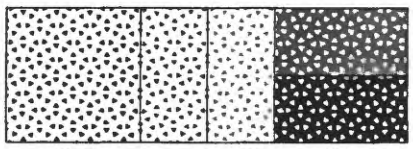

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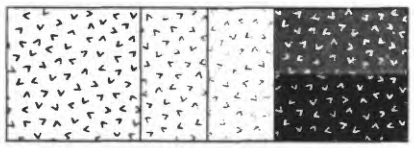

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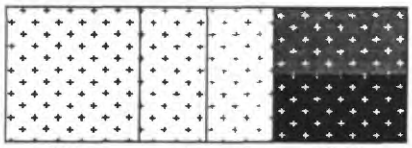

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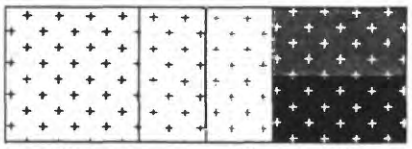

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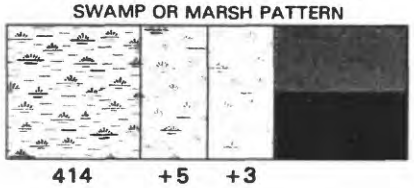

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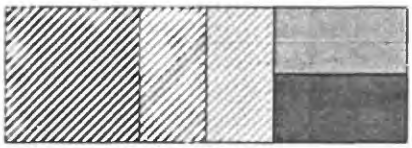

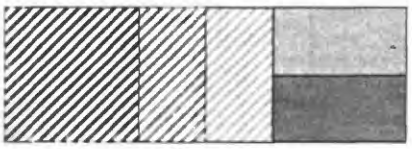

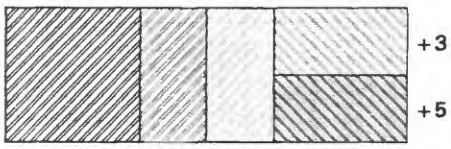

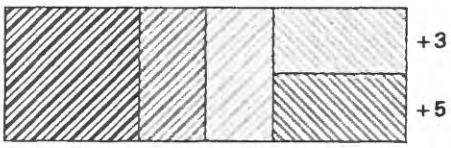

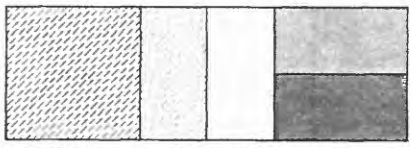

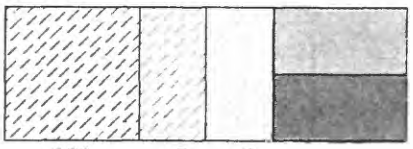

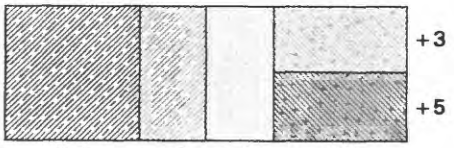

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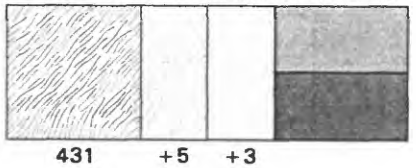

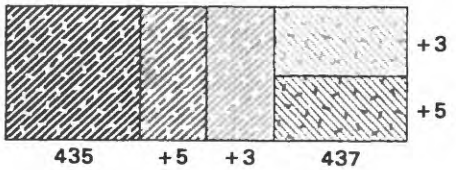

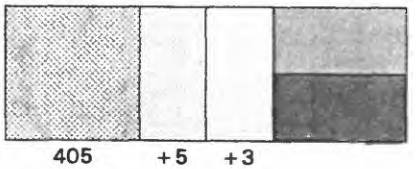

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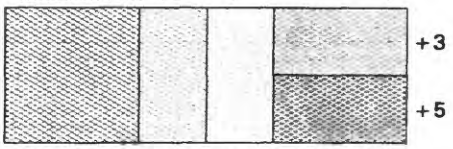
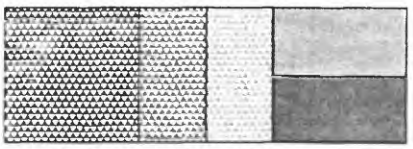
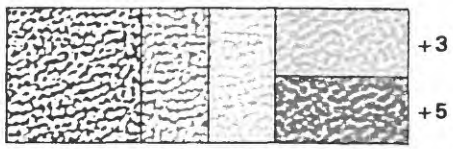
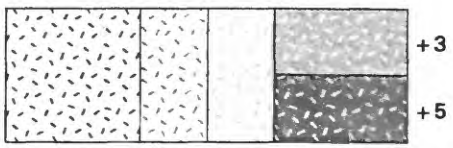
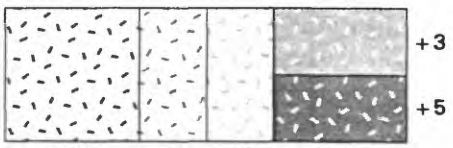
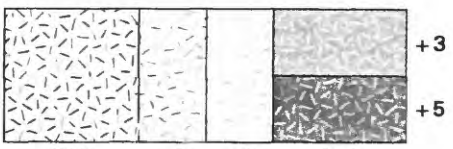


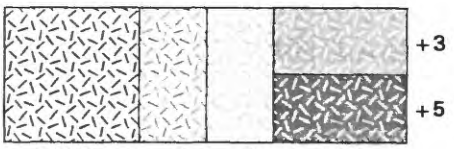


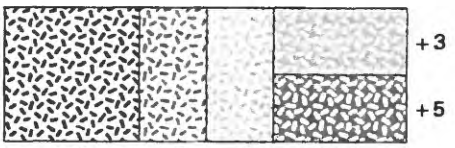


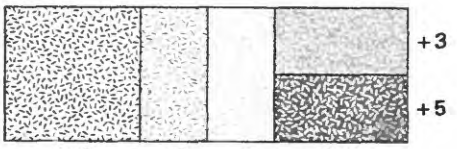




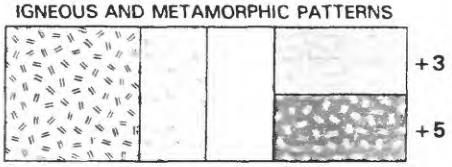


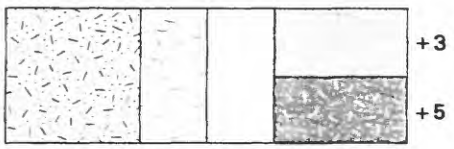


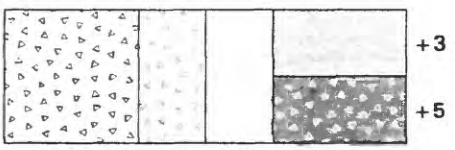


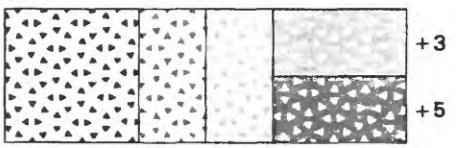


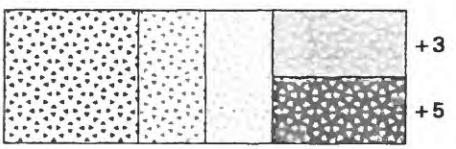
IGNEOUS AND METAMORPHIC PATTERNS



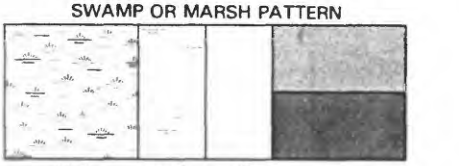


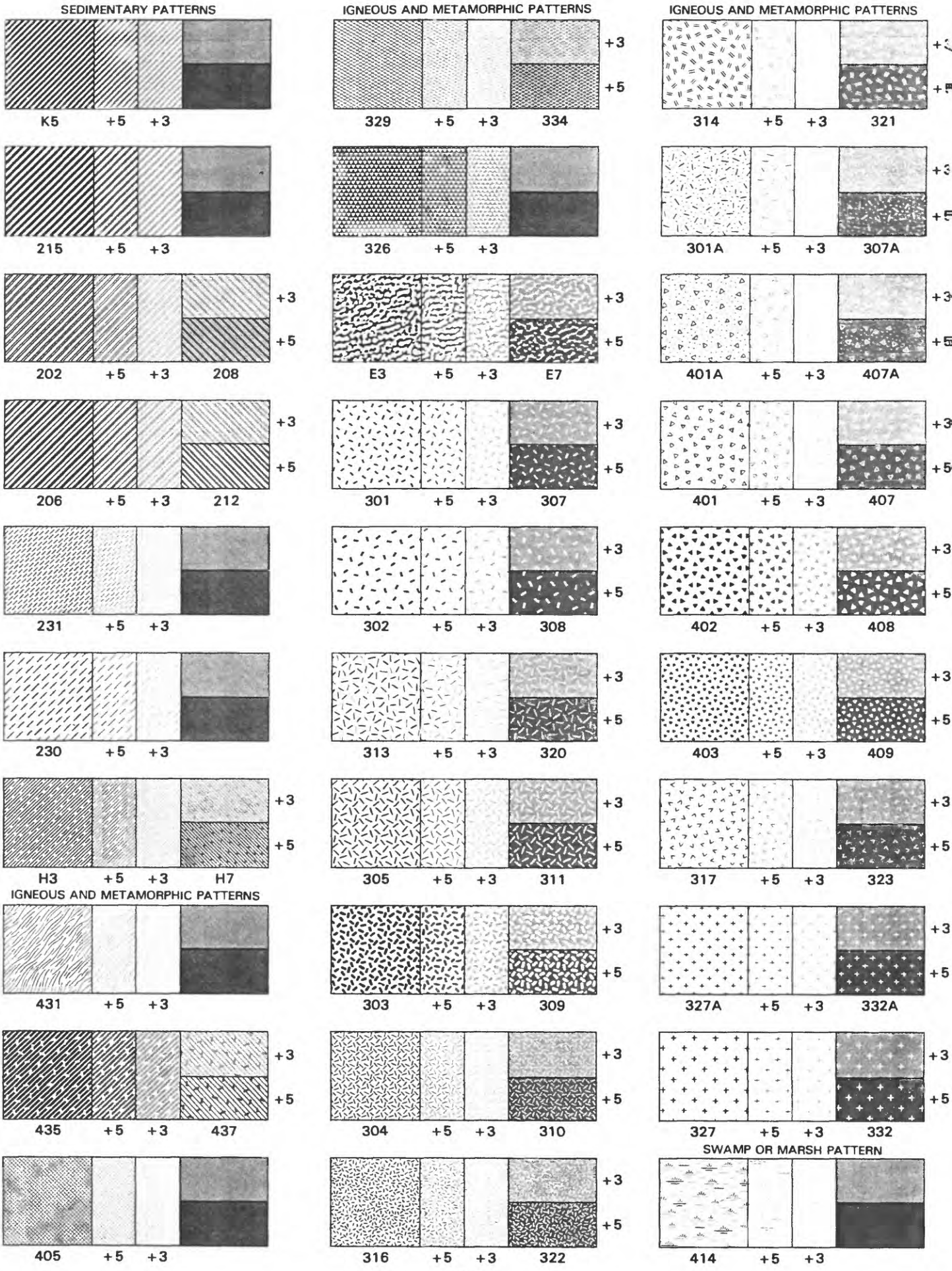




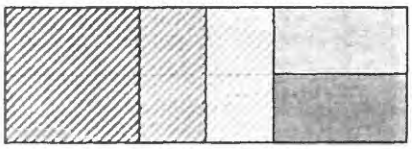


SWAMP OR MARSH PATTERN

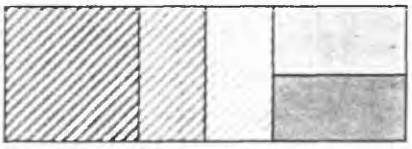



SEDIMENTARY PATTERNS
IGNEOUS AND METAMORPHIC PATTERNS
IGNEOUS AND METAMORPHIC PATTERNS
K5 +5 +3
329 +5 +3 334
314 +5 +3 321
215 +5 +3
326 +5 +3
301A +5 +3 307A
202 +5 +3 208
E3 +5 +3 E7
401A +5 +3 407A
206 +5 +3 212
301 +5 +3 307
401 +5 +3 407
231 +5 +3
302 +5 +3 308
402 +5 +3 408
230 +5 +3
313 +5 +3 320
403 +5 +3 409
H3 +5 +3 H7
305 +5 +3 311
317 +5 +3 323
IGNEOUS AND METAMORPHIC PATTERNS
431 +5 +3
303 +5 +3 309
327A +5 +3 332A
435 +5 +3 437
304 +5 +3 310
327 +5 +3 332
SWAMP OR MARSH PATTERN
405 +5 +3
316 +5 +3 322
414 +5 +3
+3
+5

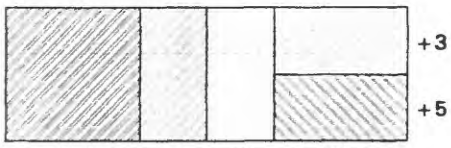
SEDIMENTARY PATTERNS



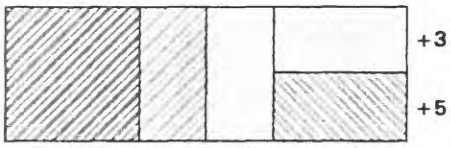
K5 +5 +3



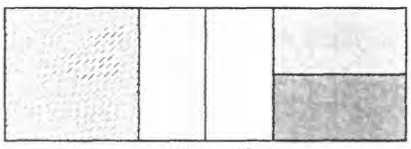
215 +5 +3



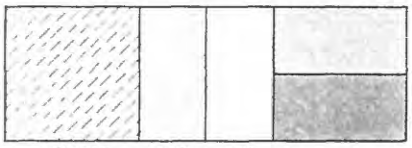
202 +5 +3 208



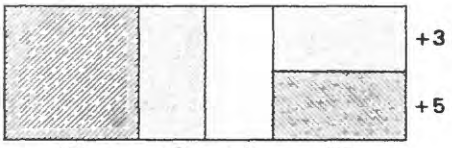
206 +5 +3 212



231 +5 +3



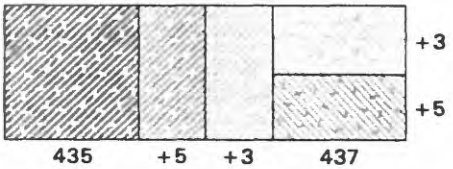
230 +5 +3



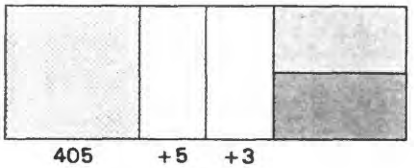
H3 +5 +3 H7

IGNEOUS AND METAMORPHIC PATTERNS

431 +5 +3

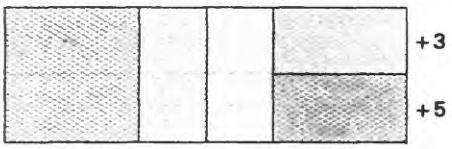


435 +5 +3 437

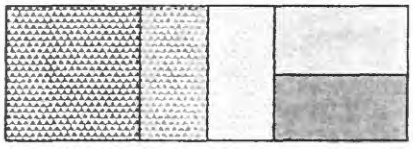


405 +5 +3

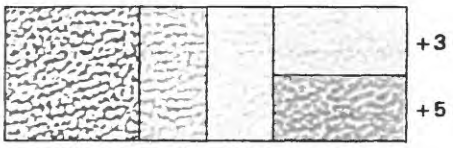
IGNEOUS AND METAMORPHIC PATTERNS



329 +5 +3 334

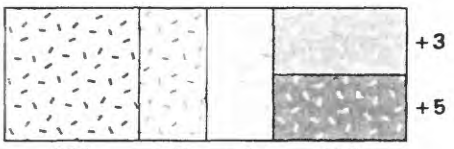


326 +5 +3



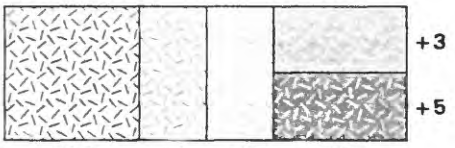
E3 +5 +3 E7

301 +5 +3 307

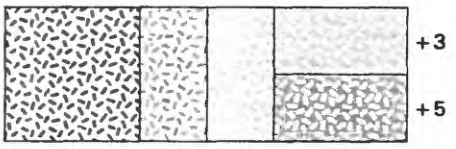


302 +5 +3 308

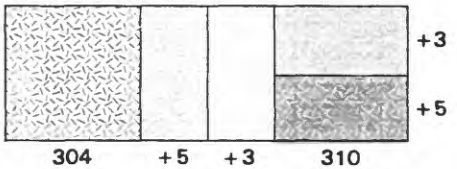
313 +5 +3 320



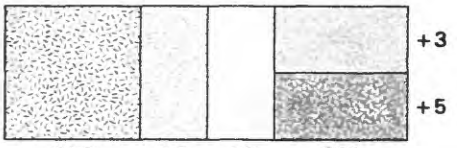
305 +5 +3 311



303 +5 +3 309

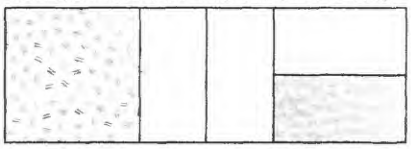


304 +5 +3 310

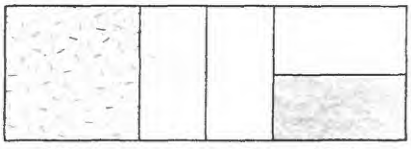


316 +5 +3 322

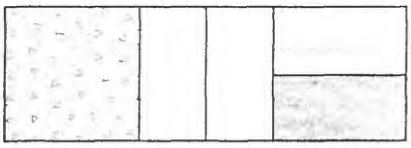
IGNEOUS AND METAMORPHIC PATTERNS



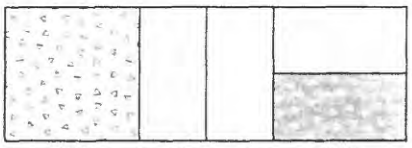
314 +5 +3 321



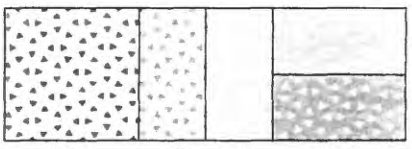
301A +5 +3 307A



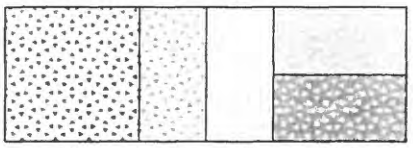
401A +5 +3 407A



401 +5 +3 407

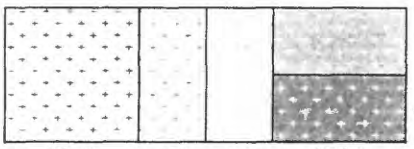


402 +5 +3 408



403 +5 +3 409

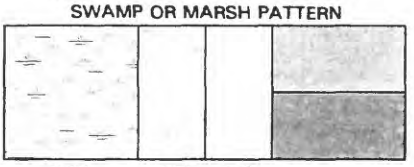
317 +5 +3 323



327A +5 +3 332A

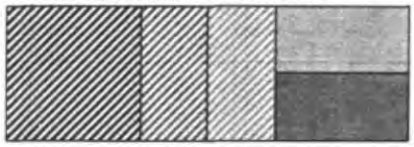
327 +5 +3 332

SWAMP OR MARSH PATTERN

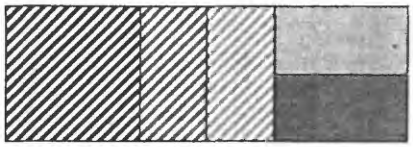


414 +5 +3

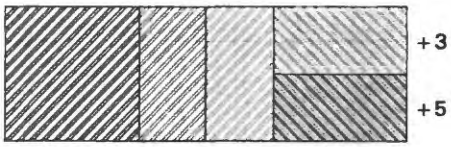
SEDIMENTARY PATTERNS



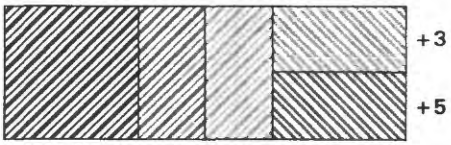
K5 +5 +3



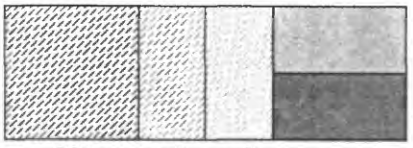
215 +5 +3



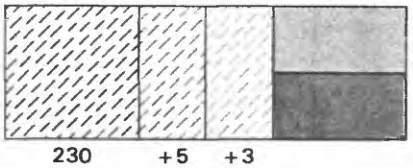
202 +5 +3 208



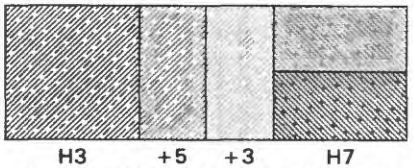
206 +5 +3 212



231 +5 +3



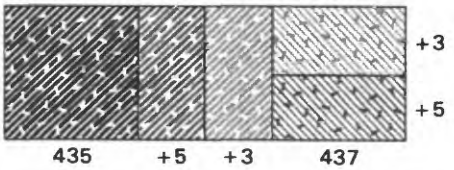
230 +5 +3



H3 +5 +3 H7

IGNEOUS AND METAMORPHIC PATTERNS

431 +5 +3

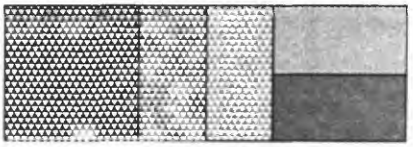


435 +5 +3 437

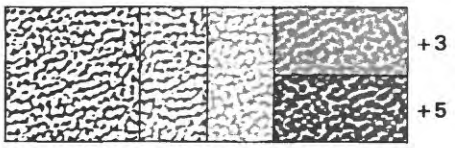
405 +5 +3

IGNEOUS AND METAMORPHIC PATTERNS

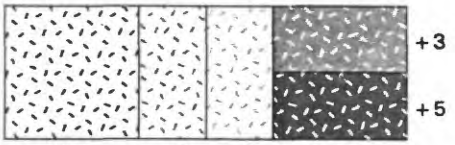
329 +5 +3 334



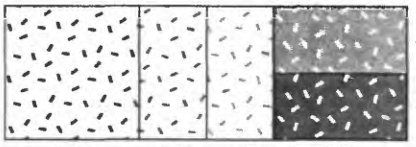
326 +5 +3



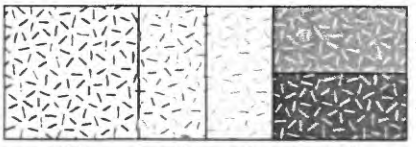
E3 +5 +3 E7



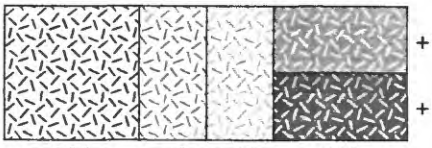
301 +5 +3 307



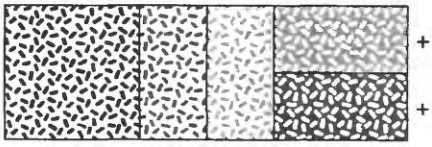
302 +5 +3 308



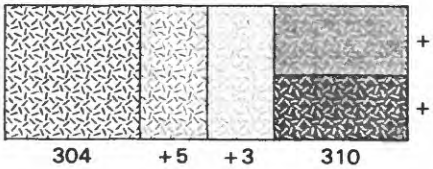
313 +5 +3 320



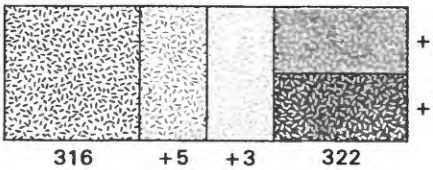
305 +5 +3 311



303 +5 +3 309

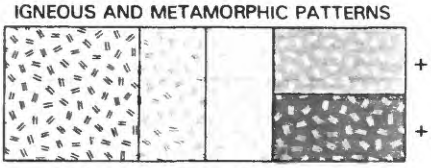


304 +5 +3 310

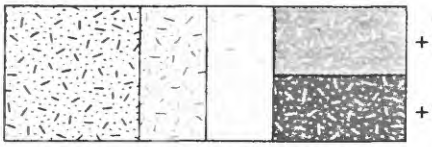


316 +5 +3 322

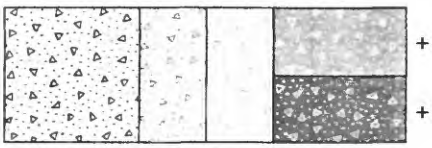
IGNEOUS AND METAMORPHIC PATTERNS



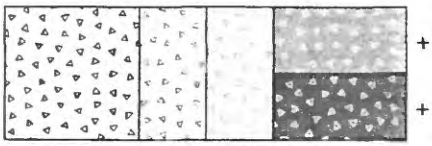
314 +5 +3 321



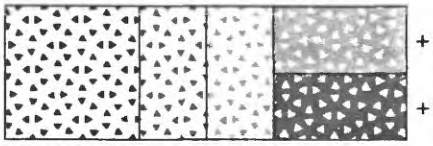
301A +5 +3 307A



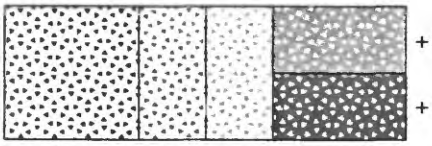
401A +5 +3 407A



401 +5 +3 407

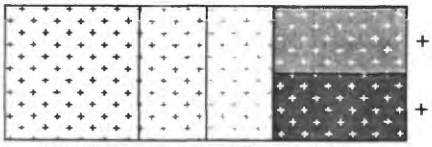


402 +5 +3 408

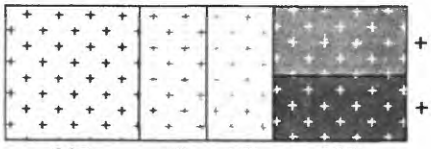


403 +5 +3 409

317 +5 +3 323

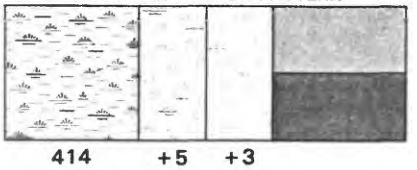


327A +5 +3 332A



327 +5 +3 332

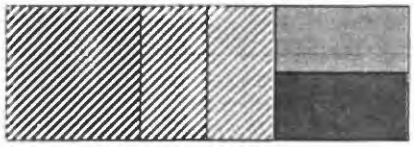
SWAMP OR MARSH PATTERN



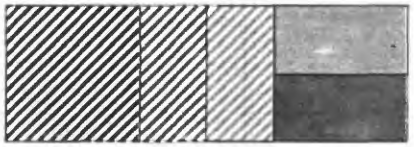
414 +5 +3

PERMANENT RED OVER
30 PERCENT PROCESS YELLOW

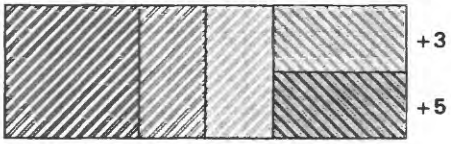
SEDIMENTARY PATTERNS



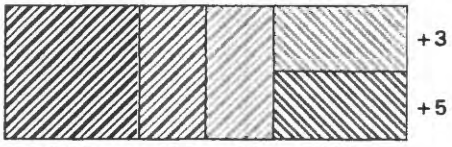
K5 +5 +3



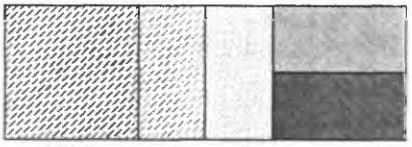
215 +5 +3



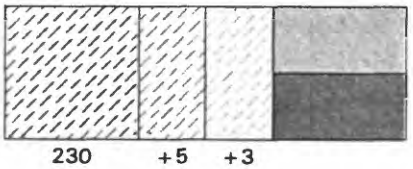
202 +5 +3 208



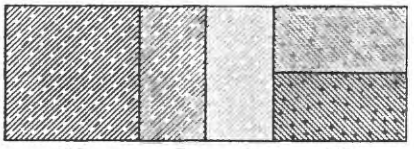
206 +5 +3 212



231 +5 +3

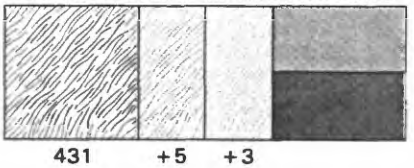


230 +5 +3

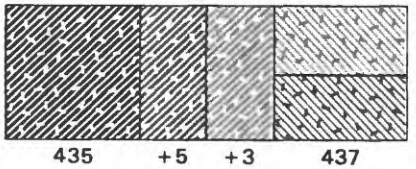


H3 +5 +3 H7

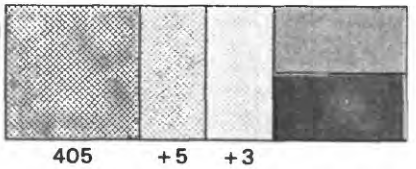
IGNEOUS AND METAMORPHIC PATTERNS



431 +5 +3

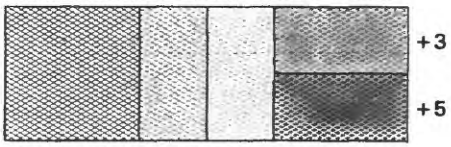


435 +5 +3 437

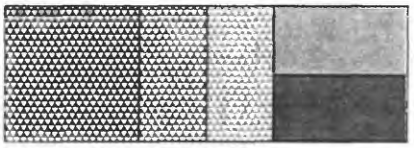


405 +5 +3

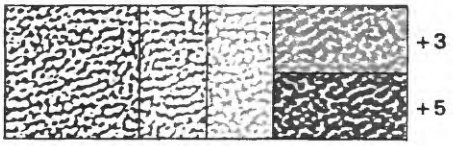
IGNEOUS AND METAMORPHIC PATTERNS



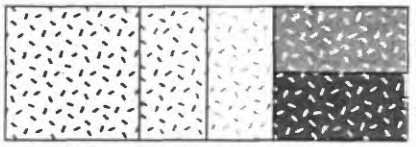
329 +5 +3 334



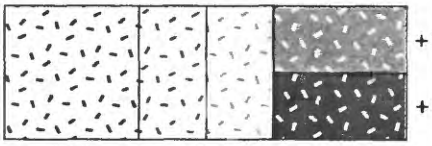
326 +5 +3



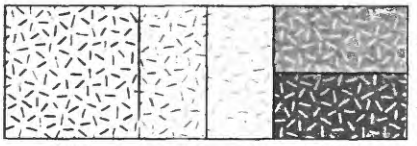
E3 +5 +3 E7



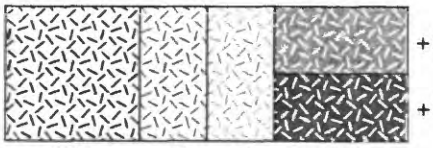
301 +5 +3 307



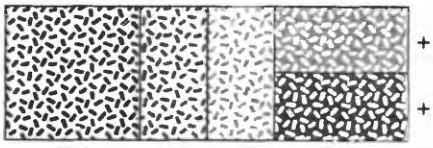
302 +5 +3 308



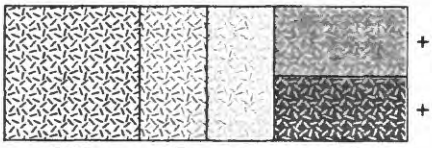
313 +5 +3 320



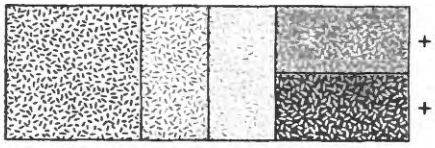
305 +5 +3 311



303 +5 +3 309

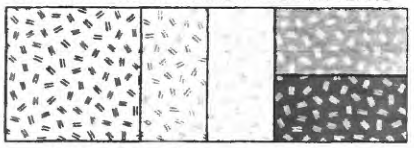


304 +5 +3 310

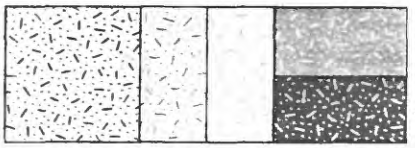


316 +5 +3 322

IGNEOUS AND METAMORPHIC PATTERNS

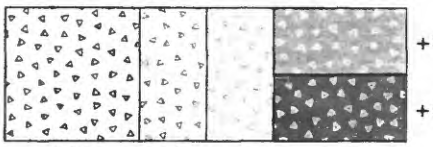


314 +5 +3 321

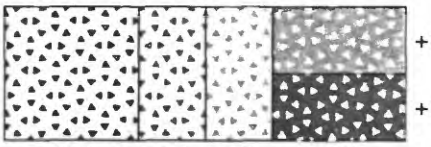


301A +5 +3 307A

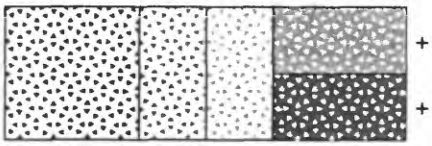
401A +5 +3 407A



401 +5 +3 407

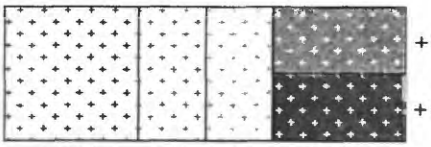


402 +5 +3 408

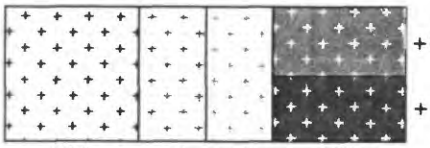


403 +5 +3 409

317 +5 +3 323



327A +5 +3 332A



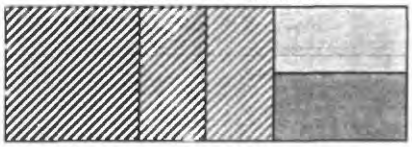
327 +5 +3 332

SWAMP OR MARSH PATTERN

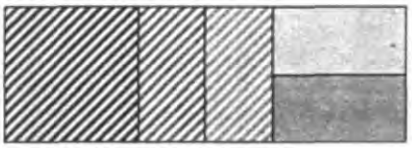
414 +5 +3

30 PERCENT PROCESS YELLOW

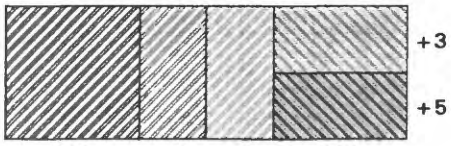
SEDIMENTARY PATTERNS



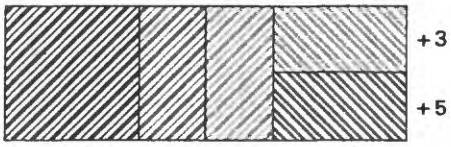
K5 +5 +3



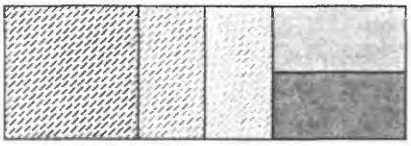
215 +5 +3



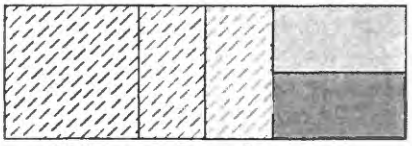
202 +5 +3 208



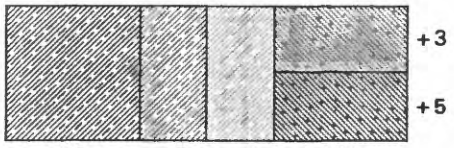
206 +5 +3 212



231 +5 +3

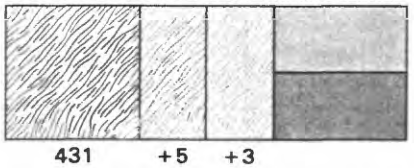


230 +5 +3

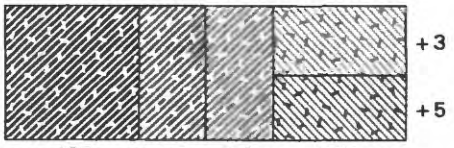


H3 +5 +3 H7

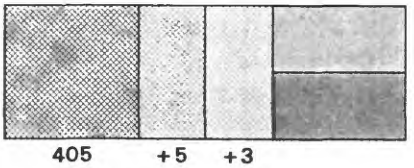
IGNEOUS AND METAMORPHIC PATTERNS



431 +5 +3

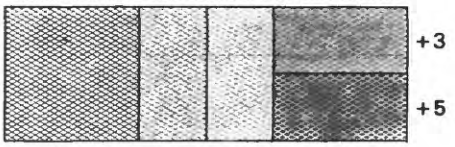


435 +5 +3 437

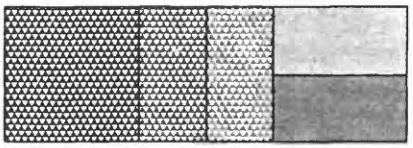


405 +5 +3

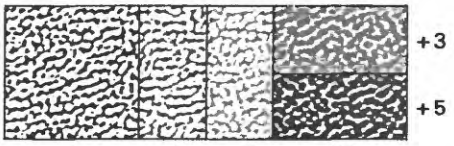
IGNEOUS AND METAMORPHIC PATTERNS



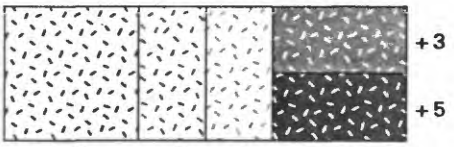
329 +5 +3 334



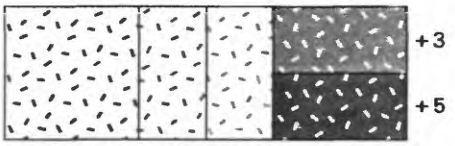
326 +5 +3



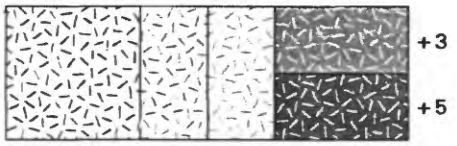
E3 +5 +3 E7



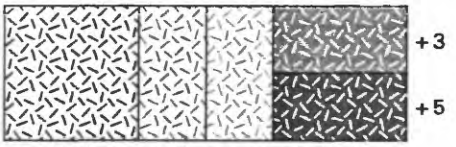
301 +5 +3 307



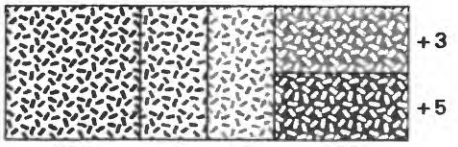
302 +5 +3 308



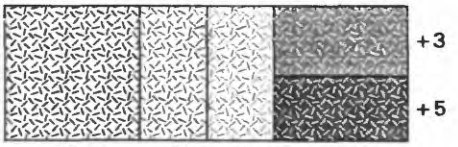
313 +5 +3 320



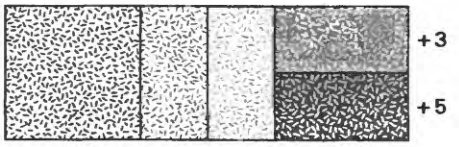
305 +5 +3 311



303 +5 +3 309

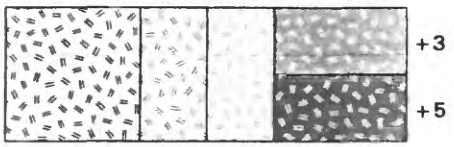


304 +5 +3 310

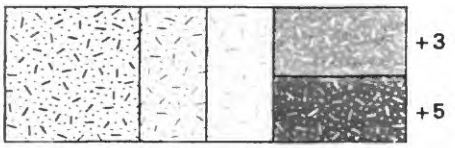


316 +5 +3 322

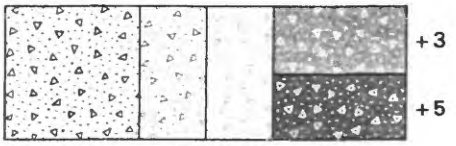
IGNEOUS AND METAMORPHIC PATTERNS



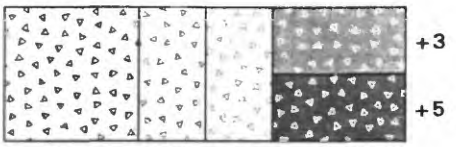
314 +5 +3 321



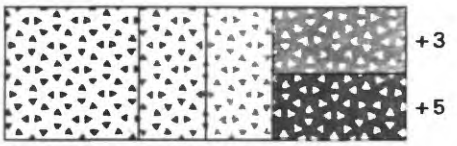
301A +5 +3 307A



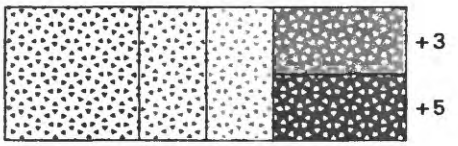
401A +5 +3 407A



401 +5 +3 407

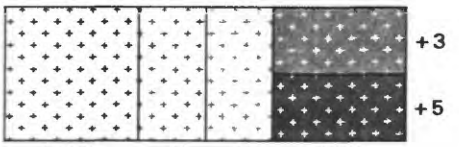


402 +5 +3 408

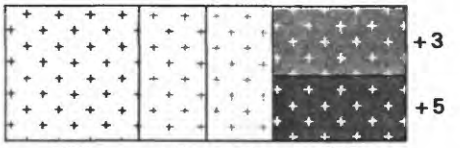


403 +5 +3 409

317 +5 +3 323

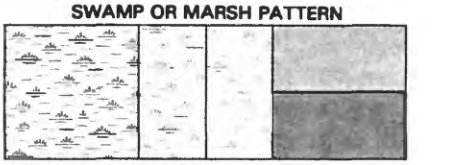


327A +5 +3 332A



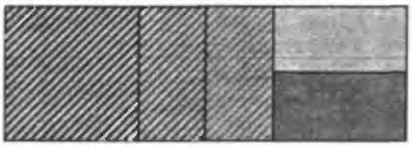
327 +5 +3 332

SWAMP OR MARSH PATTERN

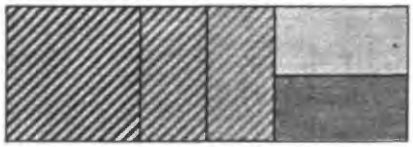


414 +5 +3

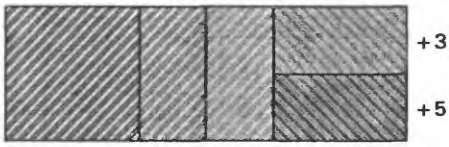
SEDIMENTARY PATTERNS



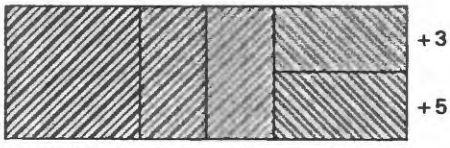
K5 +5 +3



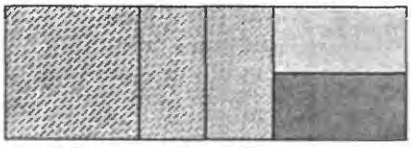
215 +5 +3



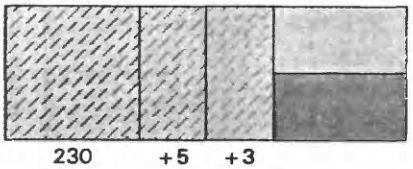
202 +5 +3 208



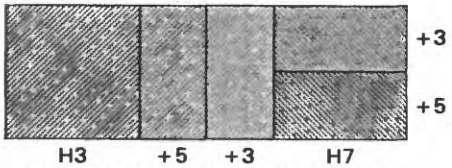
206 +5 +3 212



231 +5 +3

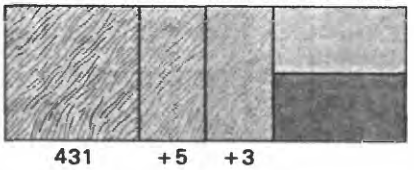


230 +5 +3

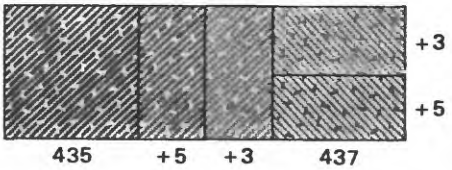


H3 +5 +3 H7

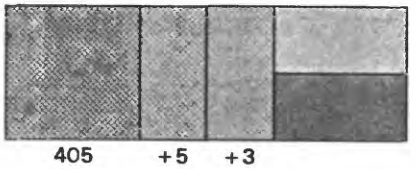
IGNEOUS AND METAMORPHIC PATTERNS



431 +5 +3

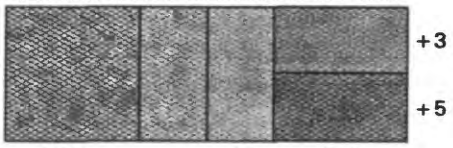


435 +5 +3 437

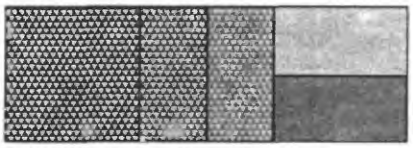


405 +5 +3

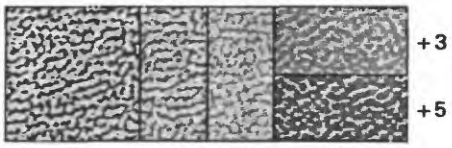
IGNEOUS AND METAMORPHIC PATTERNS



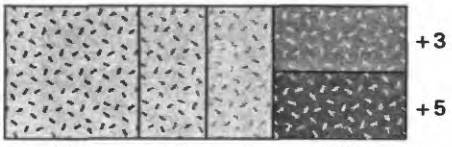
329 +5 +3 334



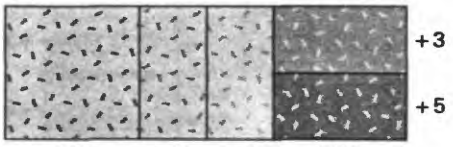
326 +5 +3



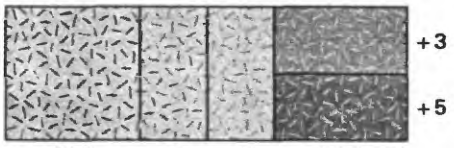
E3 +5 +3 E7



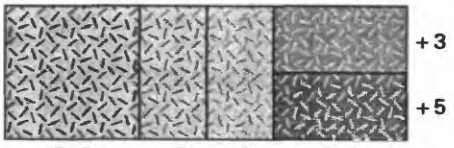
301 +5 +3 307



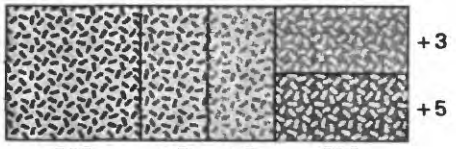
302 +5 +3 308



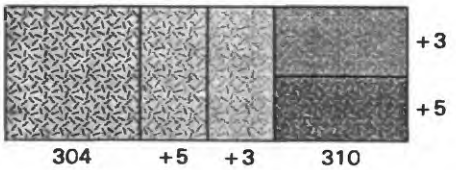
313 +5 +3 320



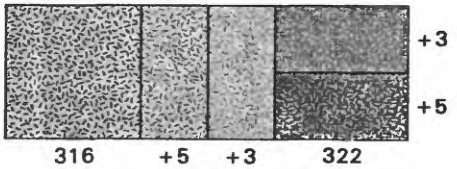
305 +5 +3 311



303 +5 +3 309

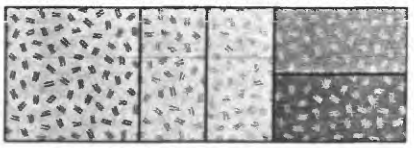


304 +5 +3 310

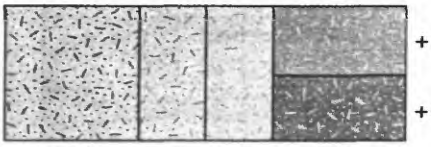


316 +5 +3 322

IGNEOUS AND METAMORPHIC PATTERNS



314 +5 +3 321



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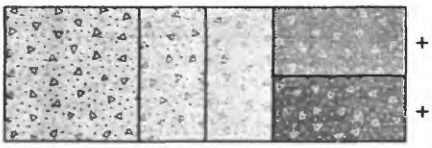
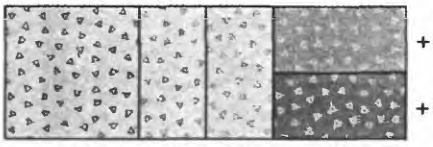
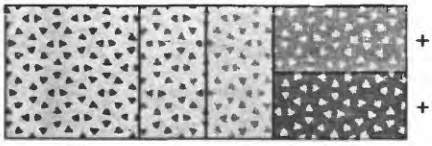


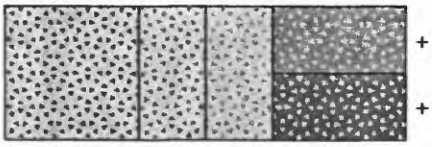
401A +5 +3 407A



401 +5 +3 407

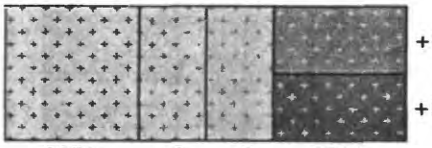


402 +5 +3 408

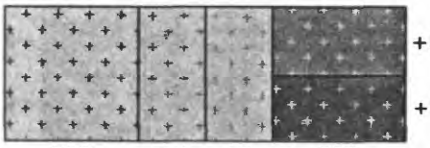


403 +5 +3 409

317 +5 +3 323

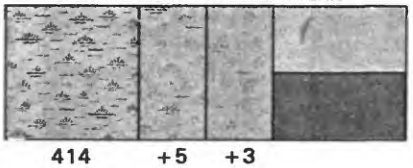


327A +5 +3 332A



327 +5 +3 332

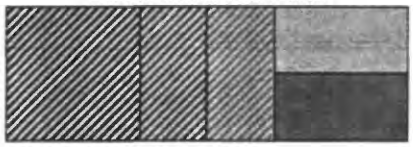
SWAMP OR MARSH PATTERN



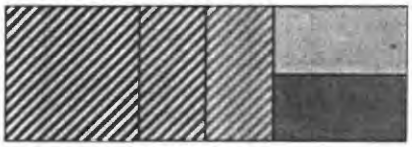
414 +5 +3

PERMANENT RED OVER
30 PERCENT PROCESS MAGENTA

SEDIMENTARY PATTERNS

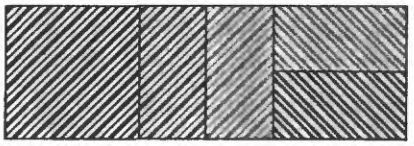


K5 +5 +3

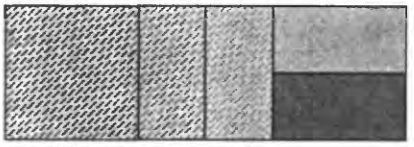


215 +5 +3

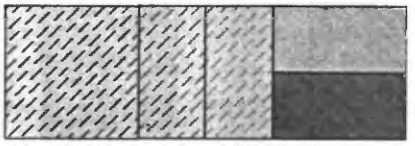
202 +5 +3 208



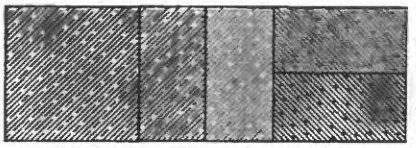
206 +5 +3 212



231 +5 +3

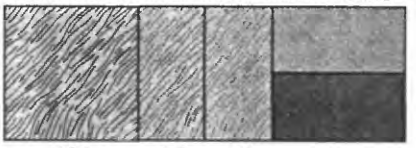


230 +5 +3

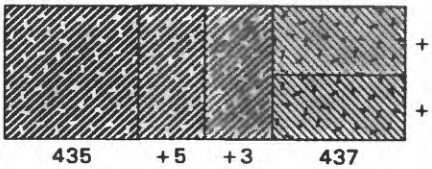


H3 +5 +3 H7

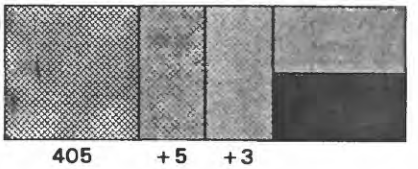
IGNEOUS AND METAMORPHIC PATTERNS



431 +5 +3

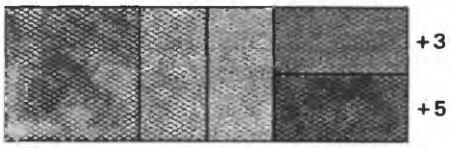


435 +5 +3 437

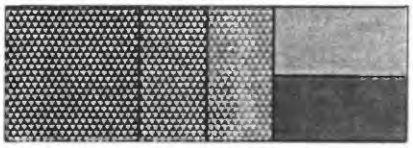


405 +5 +3

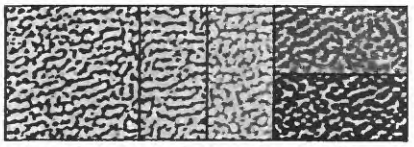
IGNEOUS AND METAMORPHIC PATTERNS



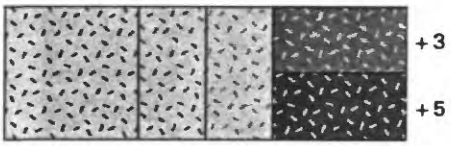
329 +5 +3 334



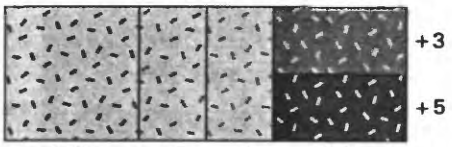
326 +5 +3



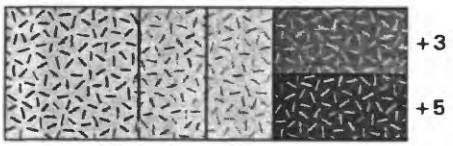
E3 +5 +3 E7



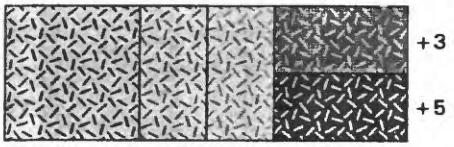
301 +5 +3 307



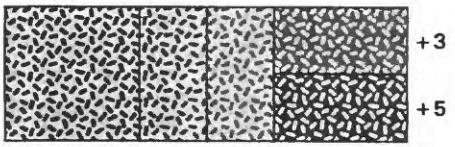
302 +5 +3 308



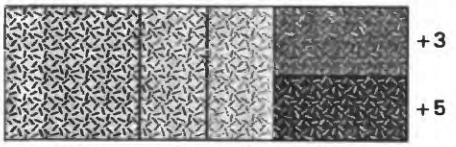
313 +5 +3 320



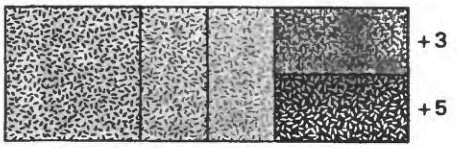
305 +5 +3 311



303 +5 +3 309

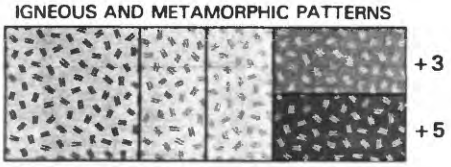


304 +5 +3 310

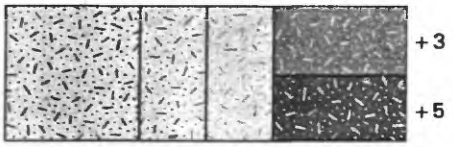


316 +5 +3 322

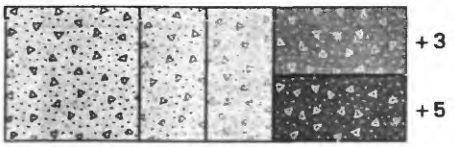
IGNEOUS AND METAMORPHIC PATTERNS



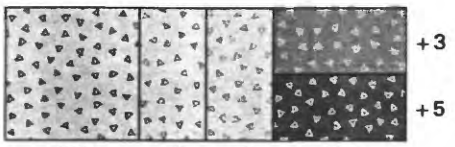
314 +5 +3 321



301A +5 +3 307A



401A +5 +3 407A



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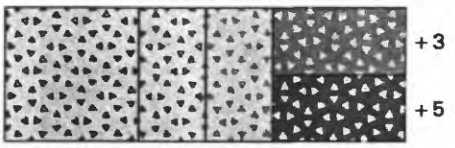
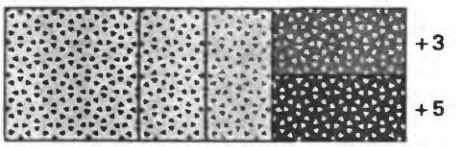
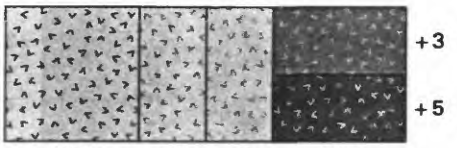


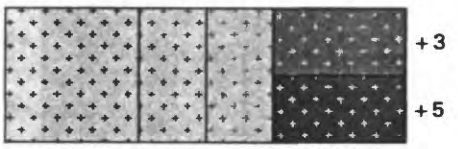
402 +5 +3 408



403 +5 +3 409



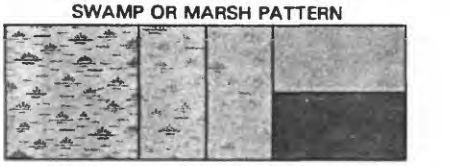
317 +5 +3 323



327A +5 +3 332A

327 +5 +3 332

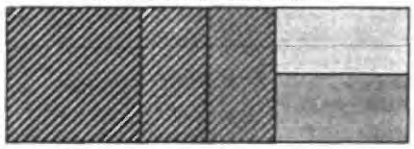
SWAMP OR MARSH PATTERN



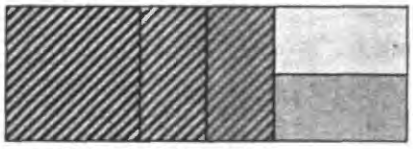
414 +5 +3

PROCESS CYAN OVER
30 PERCENT PROCESS MAGENTA

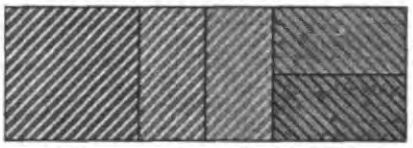
SEDIMENTARY PATTERNS



K5 +5 +3



215 +5 +3



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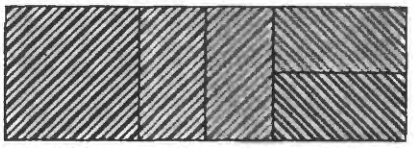

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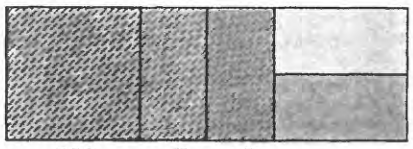

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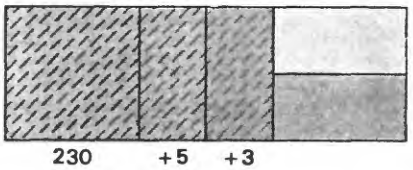

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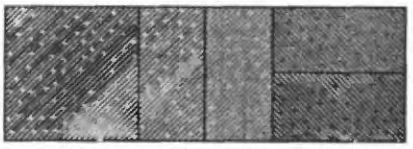
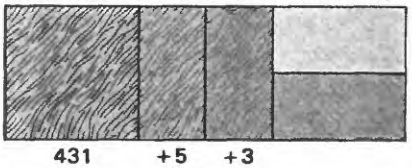


H3 +5 +3 H7

IGNEOUS AND METAMORPHIC PATTERNS



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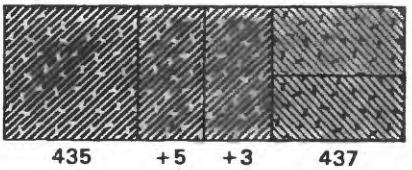

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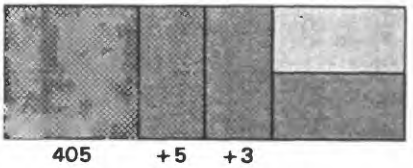
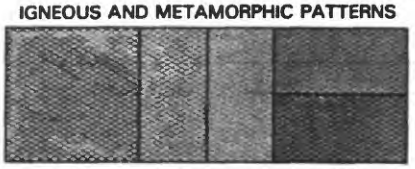
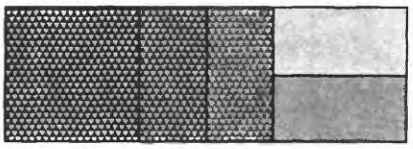


405 +5 +3

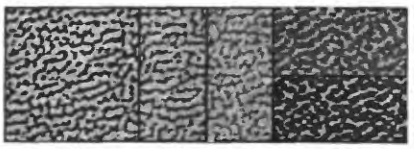
IGNEOUS AND METAMORPHIC PATTERNS



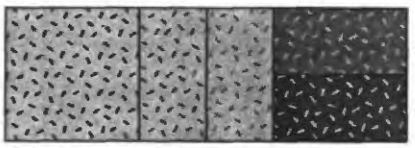
329 +5 +3 334



326 +5 +3



E3 +5 +3 E7



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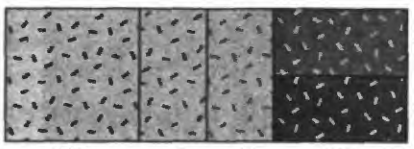

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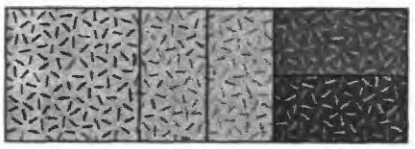

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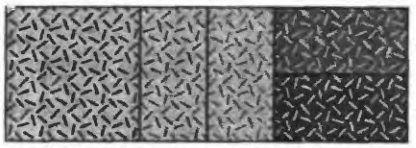

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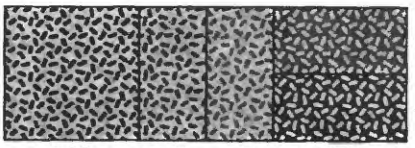
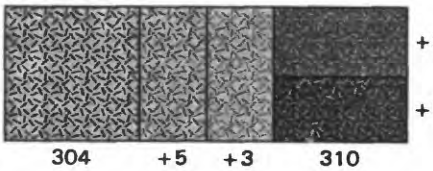


303 +5 +3 309



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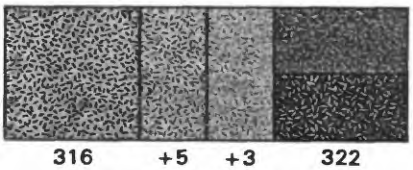
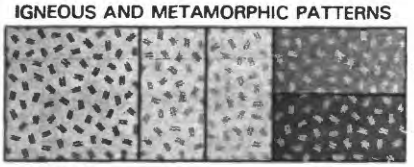


316 +5 +3 322

IGNEOUS AND METAMORPHIC PATTERNS



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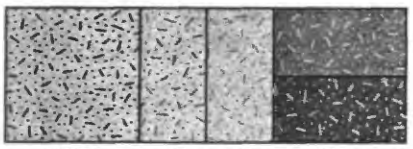

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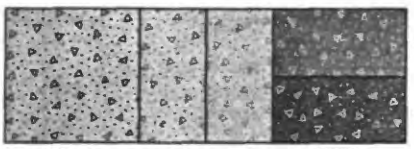

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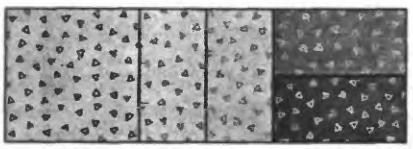
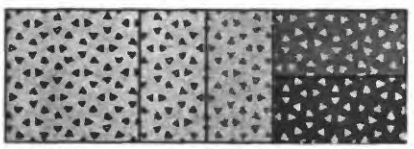


401 +5 +3 407



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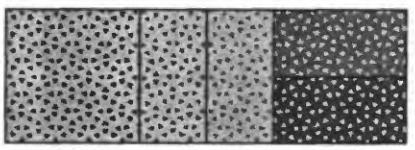

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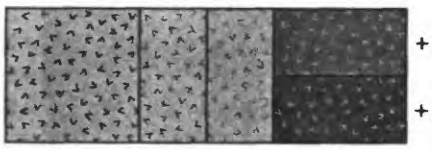
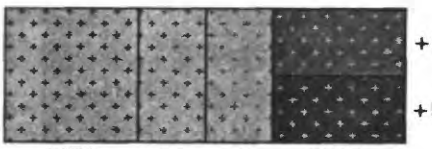


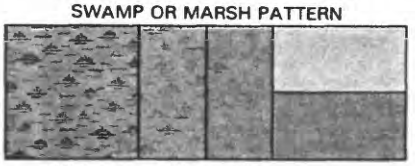
317 +5 +3 323



327A +5 +3 332A

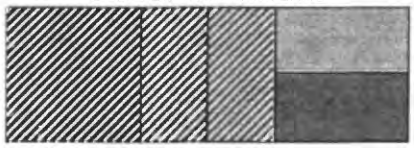
327 +5 +3 332

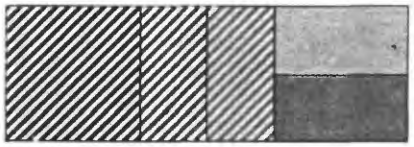
SWAMP OR MARSH PATTERN

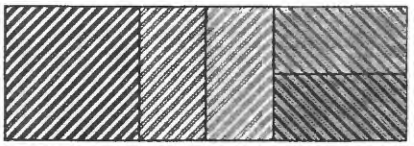


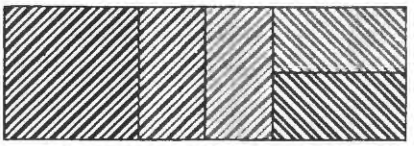
414 +5 +3

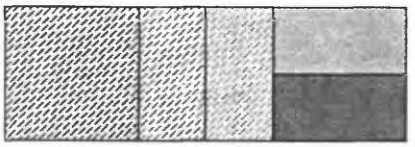
SEDIMENTARY PATTERNS

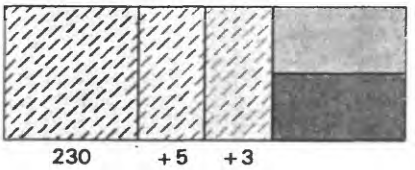


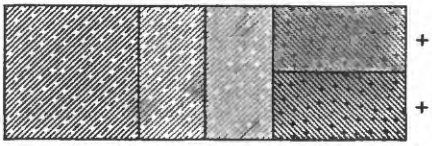




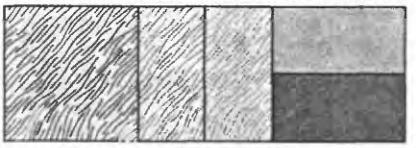


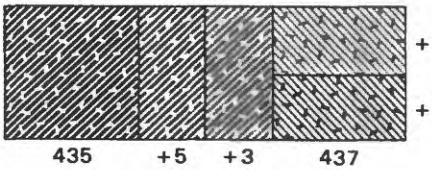


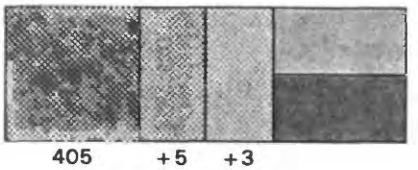




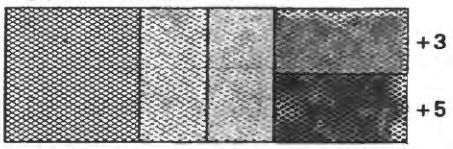
IGNEOUS AND METAMORPHIC PATTERNS

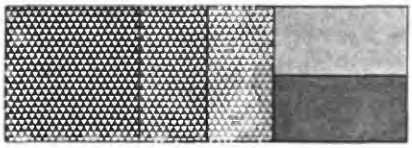


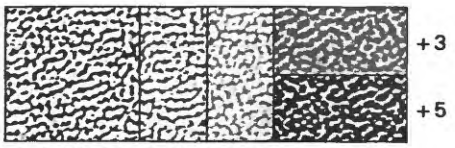


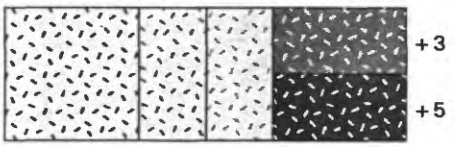


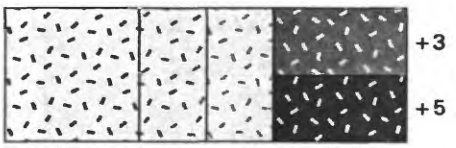
IGNEOUS AND METAMORPHIC PATTERNS

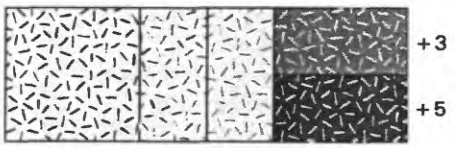


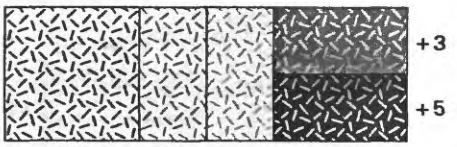


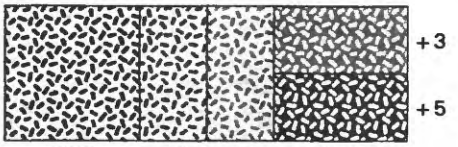


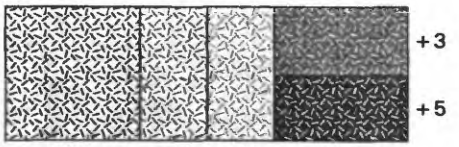


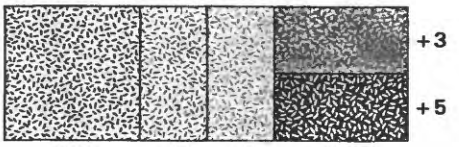




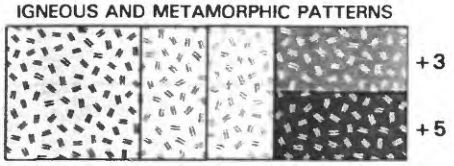


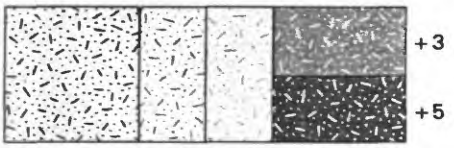


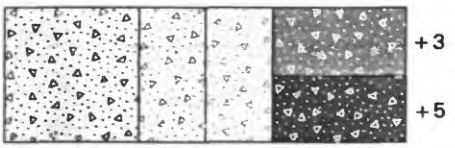


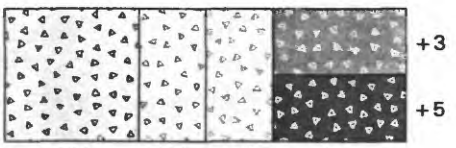


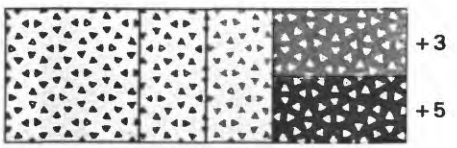
IGNEOUS AND METAMORPHIC PATTERNS

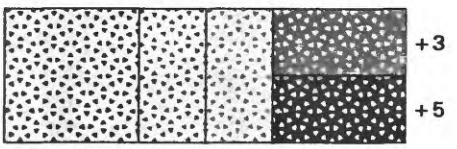


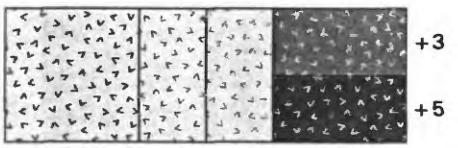


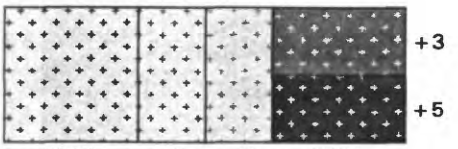




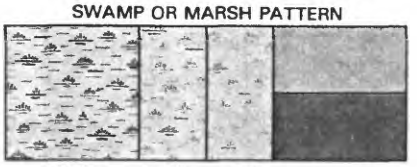




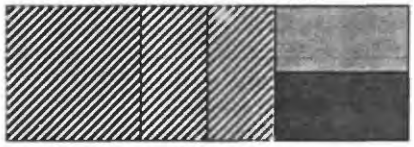




SWAMP OR MARSH PATTERN



SEDIMENTARY PATTERNS



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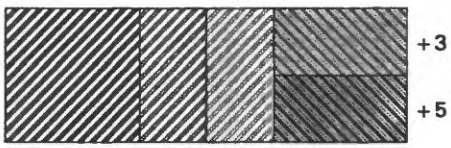
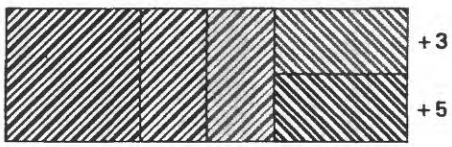
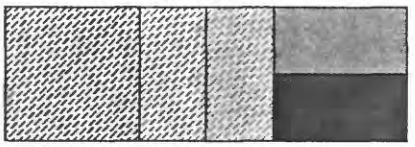
215 +5 +3



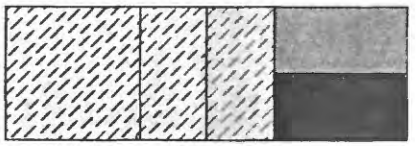
202 +5 +3 208 +3 +5



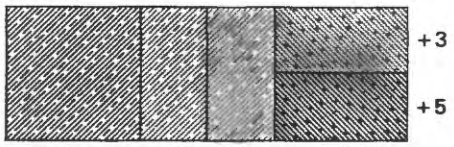
206 +5 +3 212 +3 +5



231 +5 +3

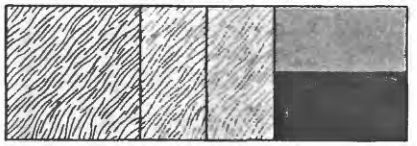


230 +5 +3

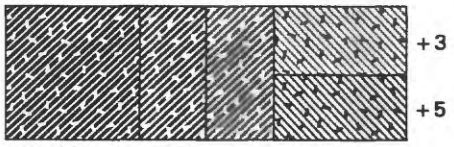


H3 +5 +3 H7 +3 +5

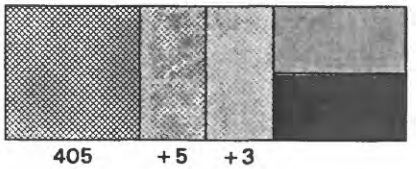
IGNEOUS AND METAMORPHIC PATTERNS



431 +5 +3

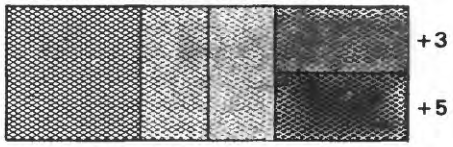


435 +5 +3 437 +3 +5

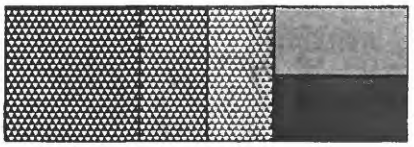


405 +5 +3

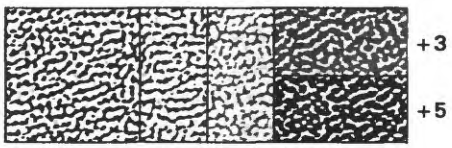
IGNEOUS AND METAMORPHIC PATTERNS



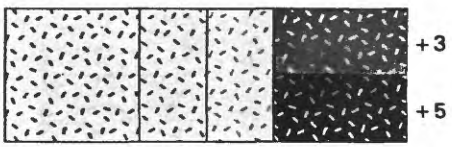
329 +5 +3 334 +3 +5



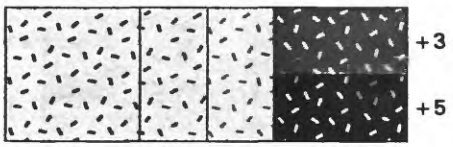
326 +5 +3



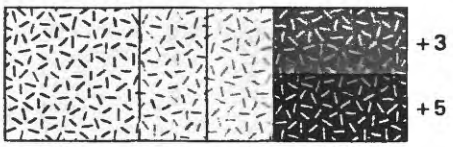
E3 +5 +3 E7 +3 +5



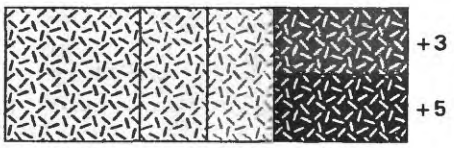
301 +5 +3 307 +3 +5



302 +5 +3 308 +3 +5



313 +5 +3 320 +3 +5



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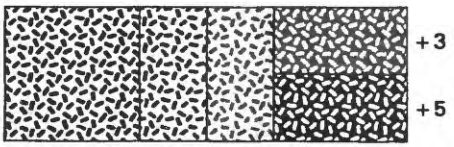

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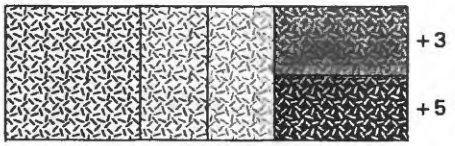

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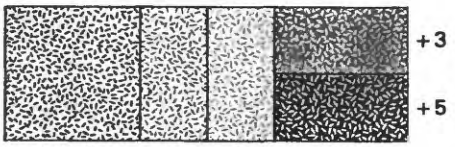
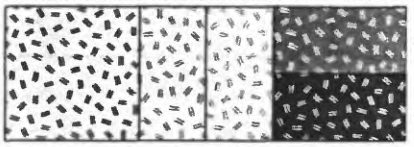


316 +5 +3 322 +3 +5

IGNEOUS AND METAMORPHIC PATTERNS



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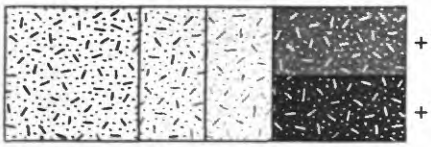
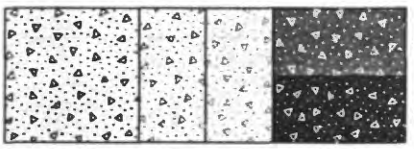


301A +5 +3 307A +3 +5



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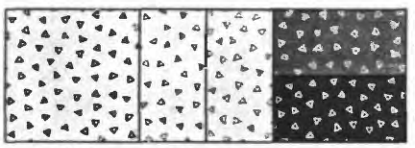

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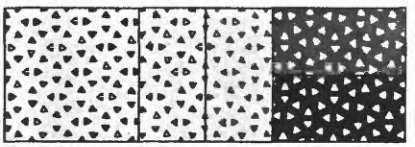

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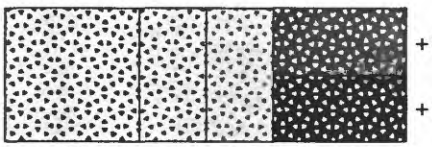

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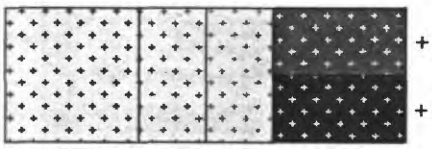
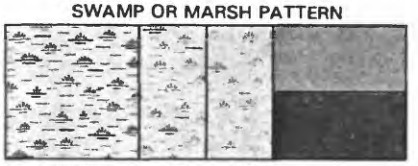
317 +5 +3 323 +3 +5



327A +5 +3 332A +3 +5

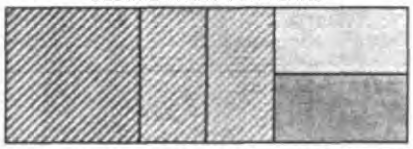
327 +5 +3 332 +3 +5

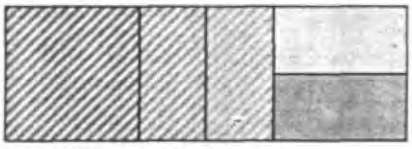
SWAMP OR MARSH PATTERN

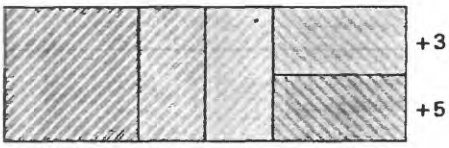


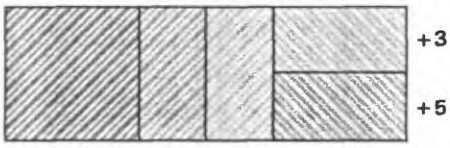
414 +5 +3

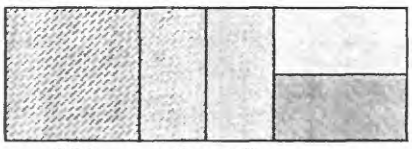
SEDIMENTARY PATTERNS

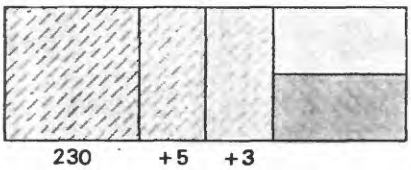


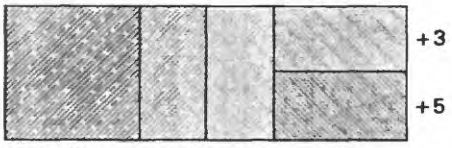




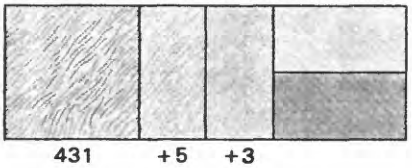


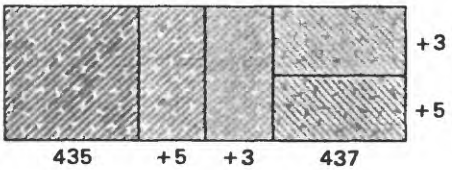


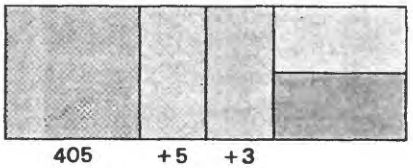




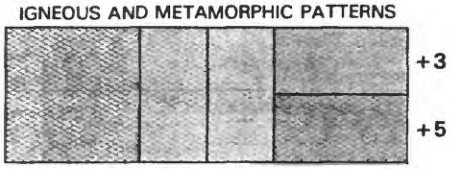
IGNEOUS AND METAMORPHIC PATTERNS

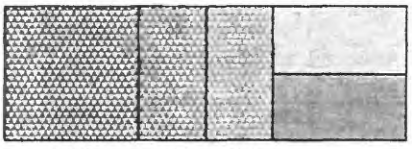


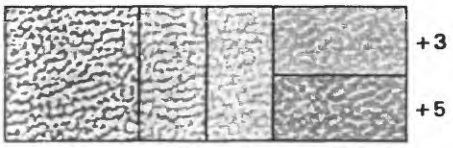


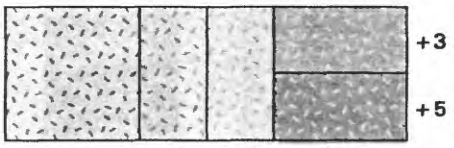


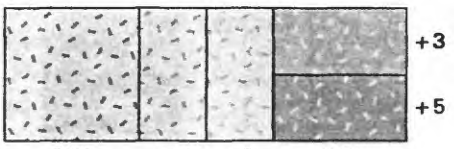
IGNEOUS AND METAMORPHIC PATTERNS

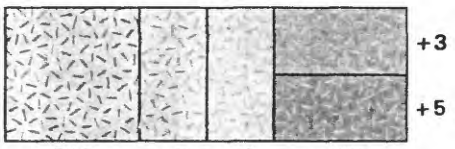


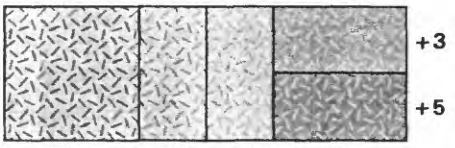


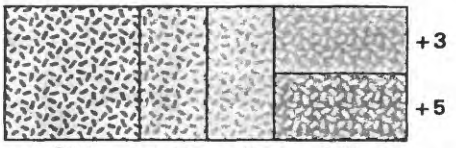


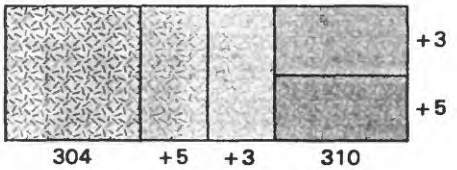


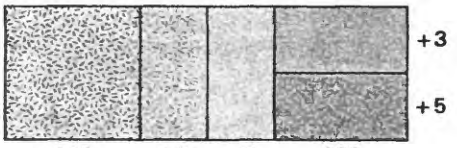




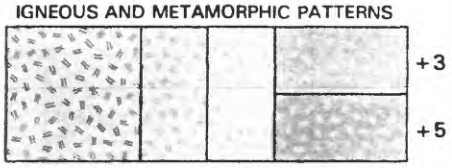


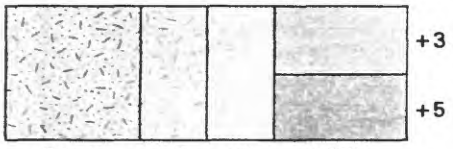


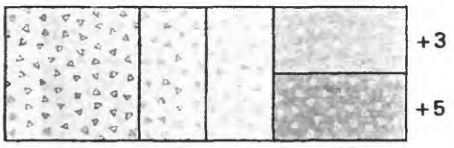


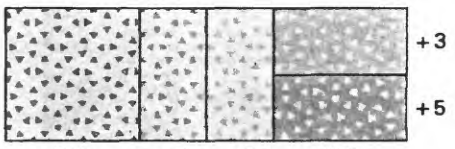


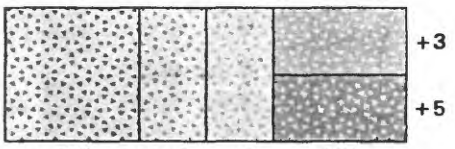
IGNEOUS AND METAMORPHIC PATTERNS

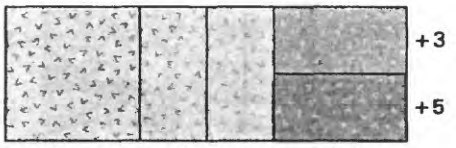


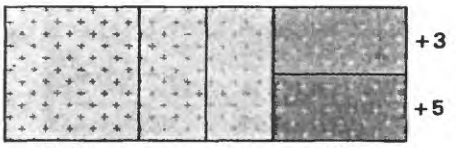




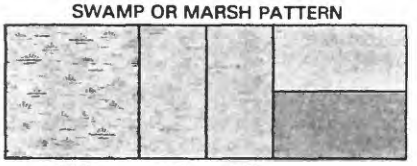




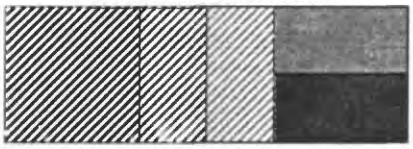


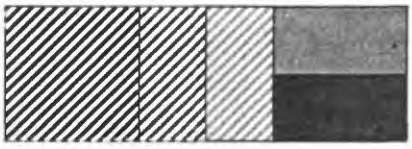


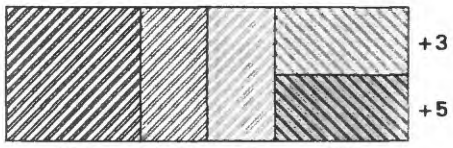
SWAMP OR MARSH PATTERN

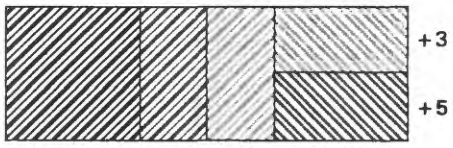


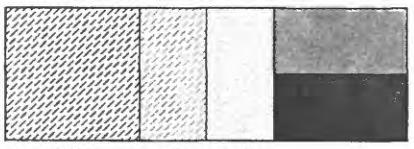
SEDIMENTARY PATTERNS

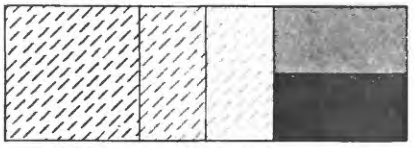


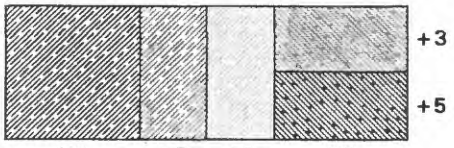




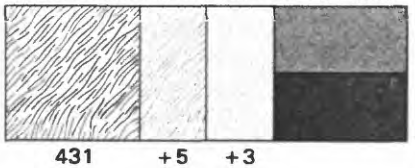


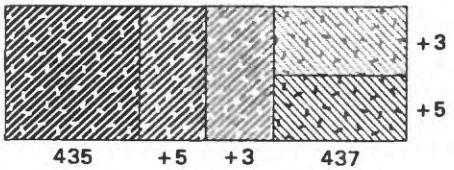


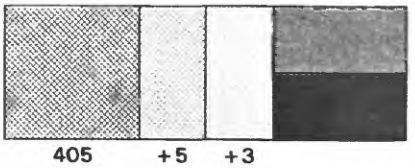




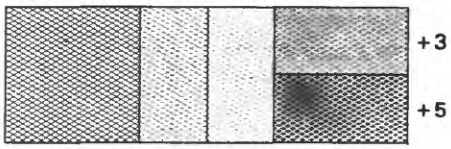
IGNEOUS AND METAMORPHIC PATTERNS

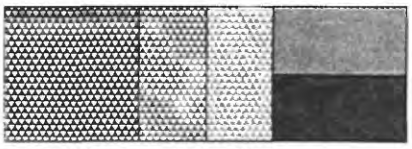


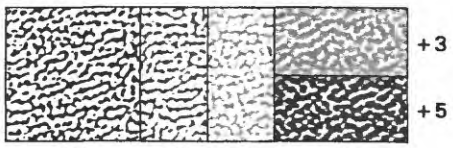


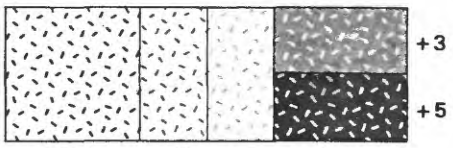


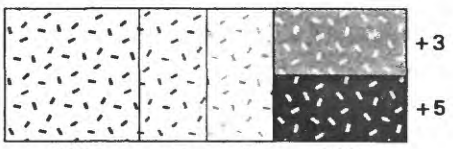
IGNEOUS AND METAMORPHIC PATTERNS

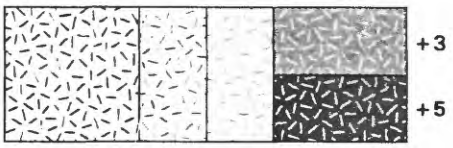


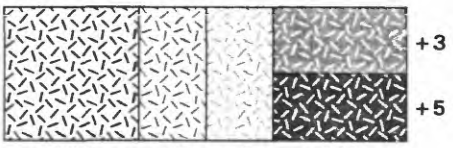


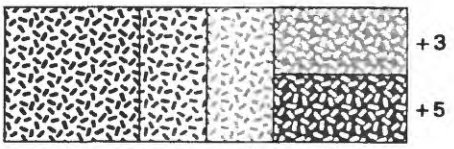


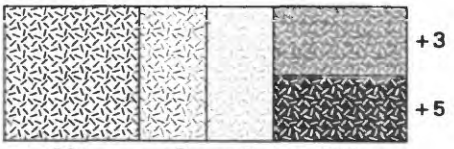


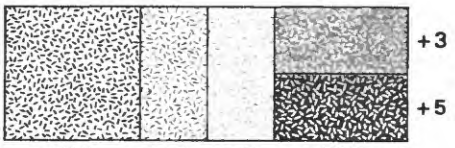




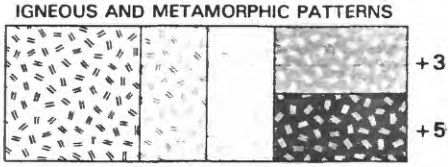


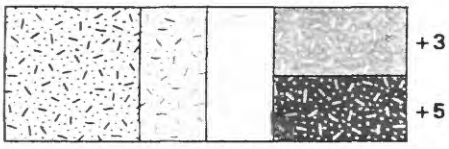


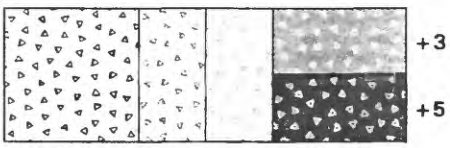


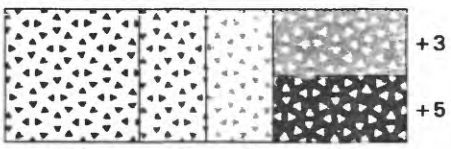


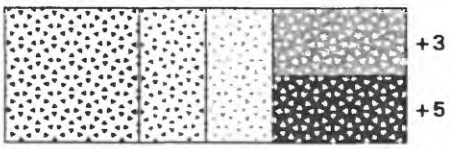
IGNEOUS AND METAMORPHIC PATTERNS

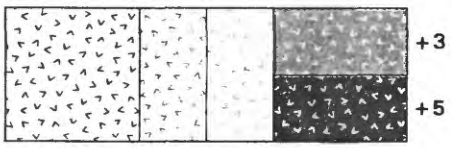


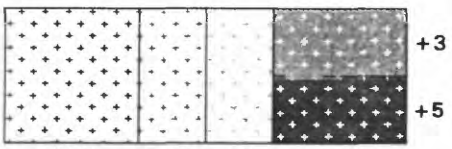


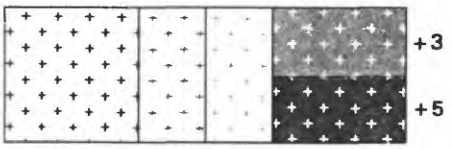




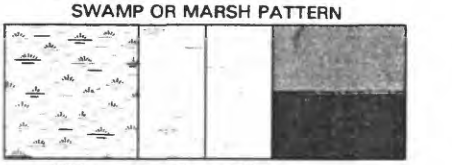




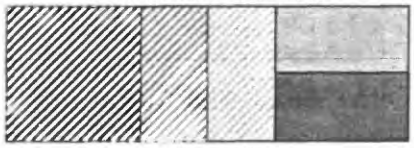




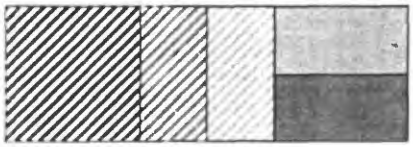
SWAMP OR MARSH PATTERN



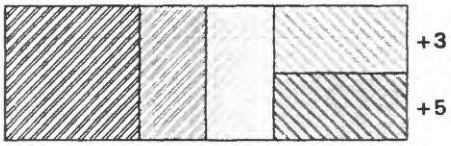
SEDIMENTARY PATTERNS



K5 +5 +3



215 +5 +3



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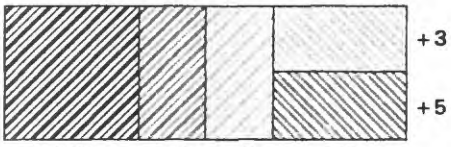
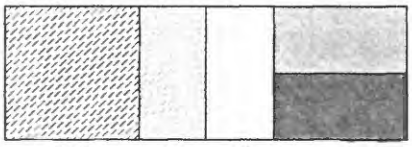
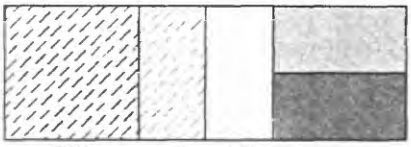


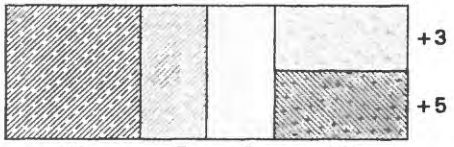
206 +5 +3 212



231 +5 +3

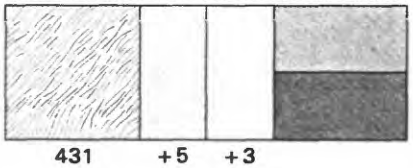


230 +5 +3

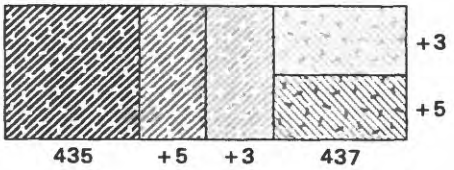


H3 +5 +3 H7

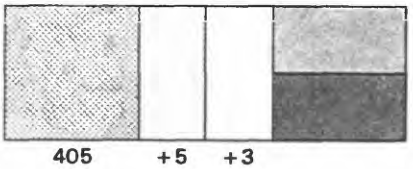
IGNEOUS AND METAMORPHIC PATTERNS



431 +5 +3

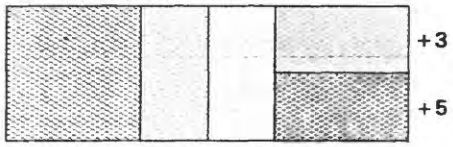


435 +5 +3 437



405 +5 +3

IGNEOUS AND METAMORPHIC PATTERNS



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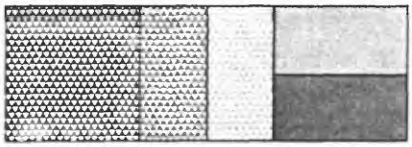
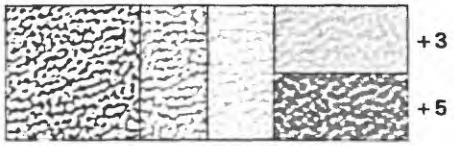
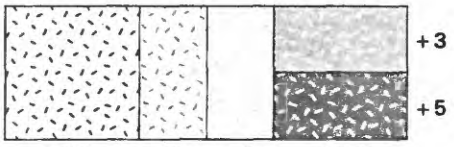


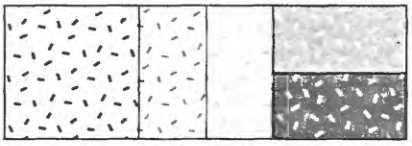
326 +5 +3



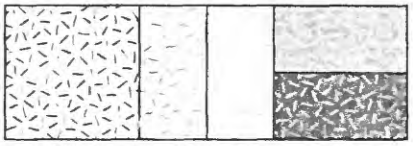
E3 +5 +3 E7



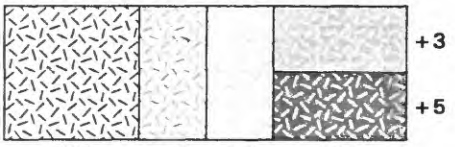
301 +5 +3 307



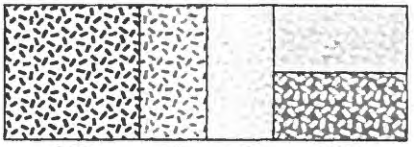
302 +5 +3 308



313 +5 +3 320



305 +5 +3 311



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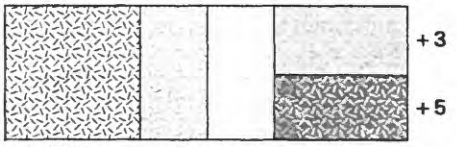
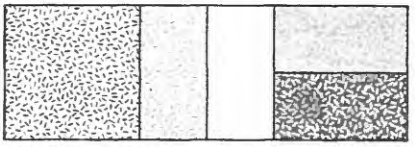
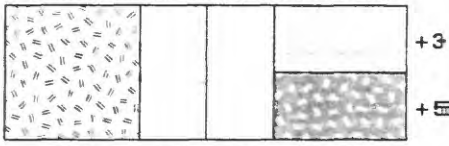


304 +5 +3 310

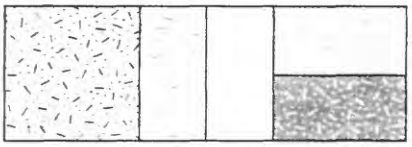


316 +5 +3 322

IGNEOUS AND METAMORPHIC PATTERNS



314 +5 +3 321



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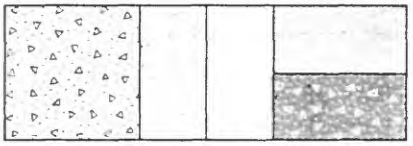

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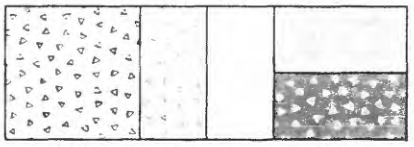
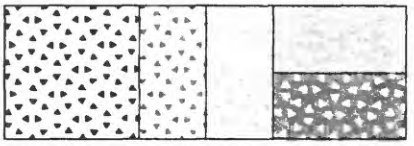
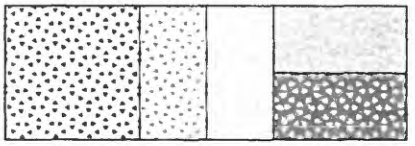


401 +5 +3 407

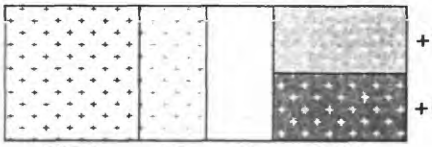


402 +5 +3 408

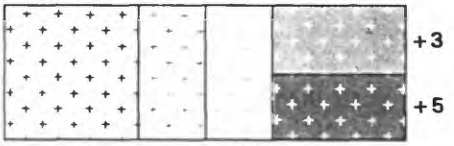


403 +5 +3 409

317 +5 +3 323

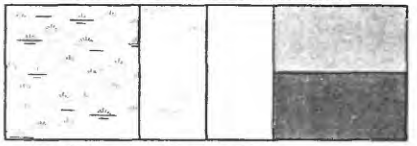


327A +5 +3 332A



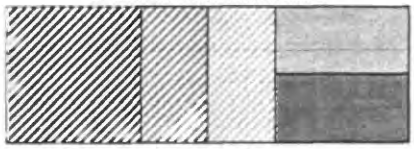
327 +5 +3 332

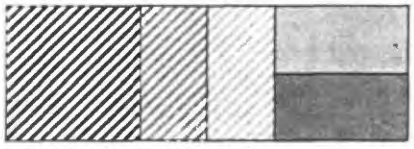
SWAMP OR MARSH PATTERN

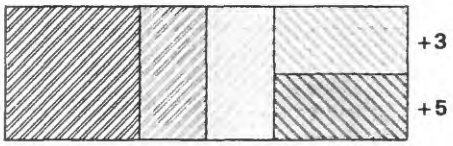


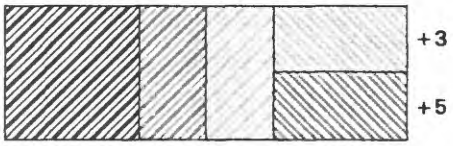
414 +5 +3

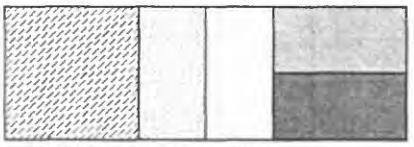
SEDIMENTARY PATTERNS

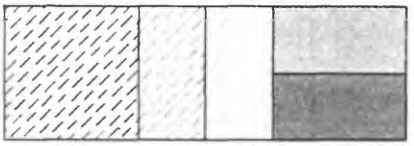


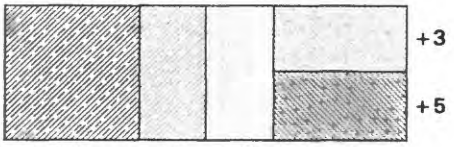




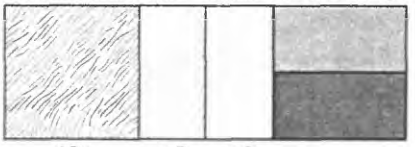


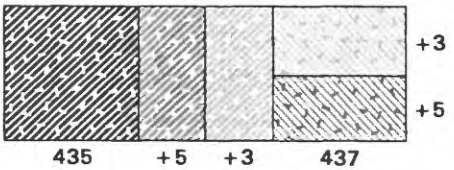


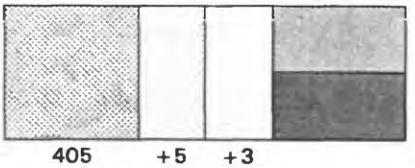




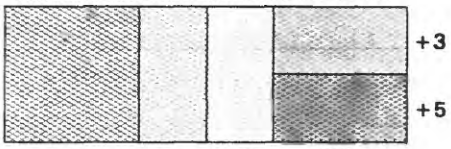
IGNEOUS AND METAMORPHIC PATTERNS

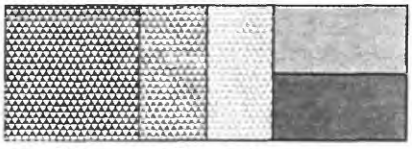


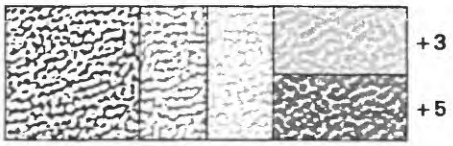


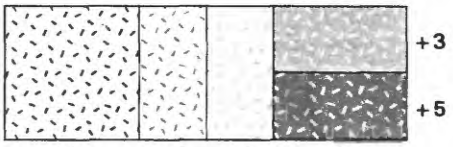


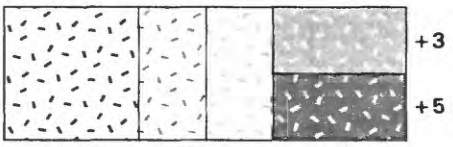
IGNEOUS AND METAMORPHIC PATTERNS

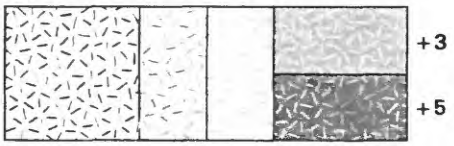


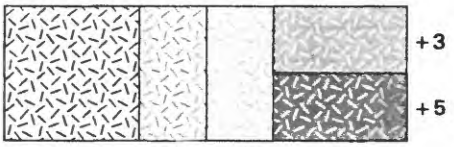


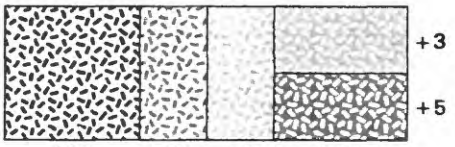


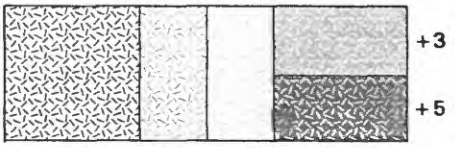


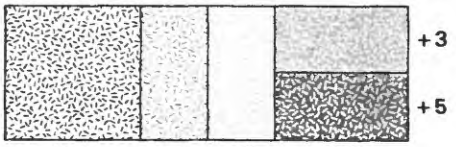




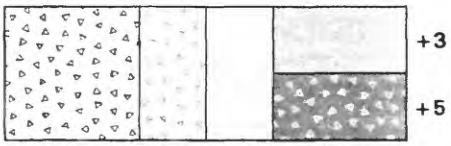


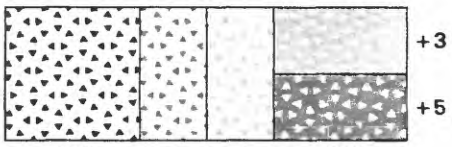


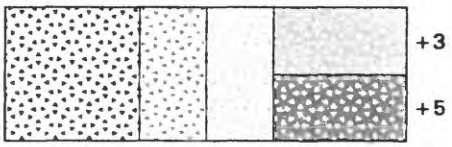


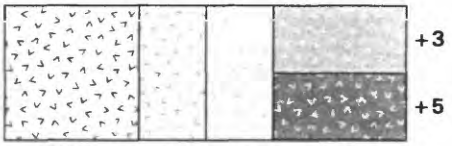


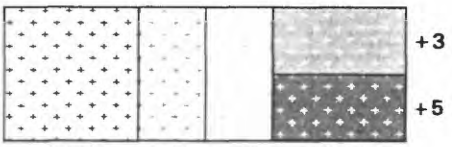
IGNEOUS AND METAMORPHIC PATTERNS



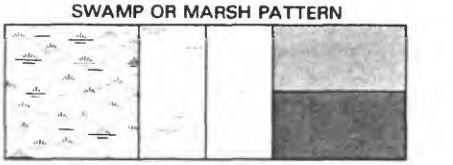




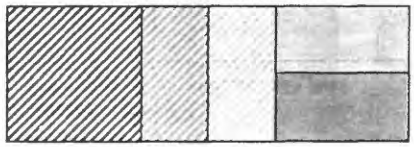




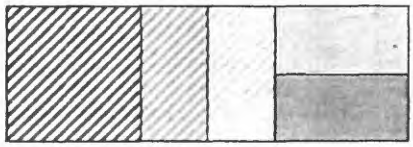
SWAMP OR MARSH PATTERN



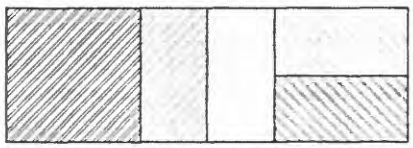
SEDIMENTARY PATTERNS



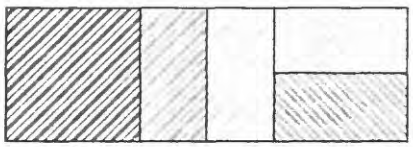
K5 +5 +3



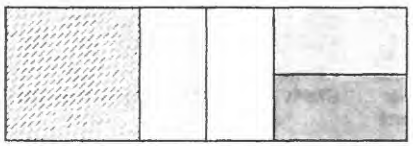
215 +5 +3



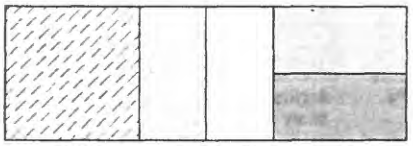
202 +5 +3 208 +3 +5



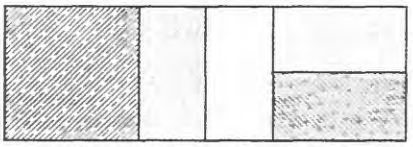
206 +5 +3 212 +3 +5



231 +5 +3

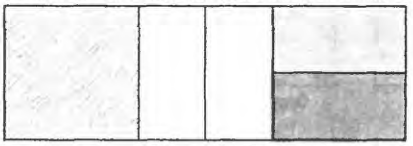


230 +5 +3

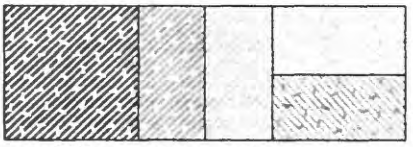


H3 +5 +3 H7 +3 +5

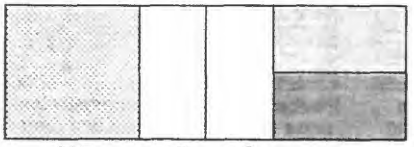
IGNEOUS AND METAMORPHIC PATTERNS



431 +5 +3

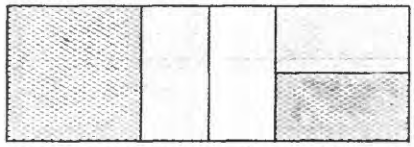


435 +5 +3 437 +3 +5

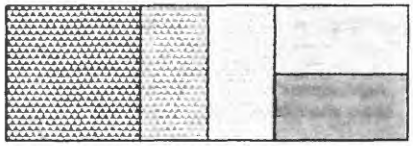


405 +5 +3

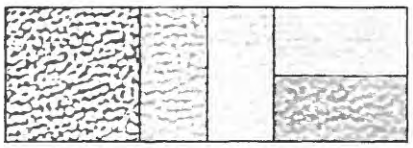
IGNEOUS AND METAMORPHIC PATTERNS



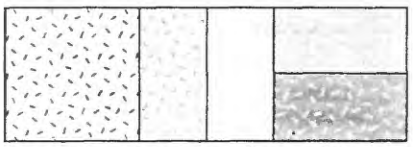
329 +5 +3 334 +3 +5



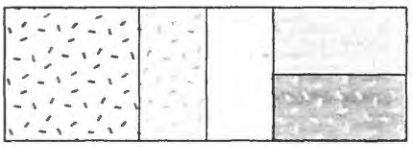
326 +5 +3



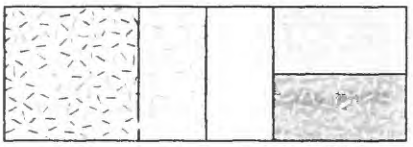
E3 +5 +3 E7 +3 +5



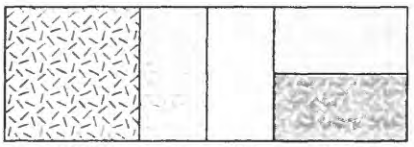
301 +5 +3 307 +3 +5



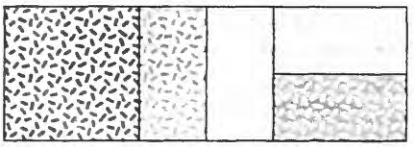
302 +5 +3 308 +3 +5



313 +5 +3 320 +3 +5



305 +5 +3 311 +3 +5



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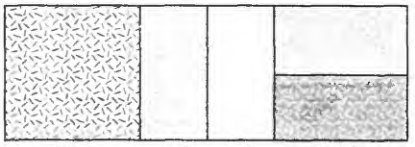

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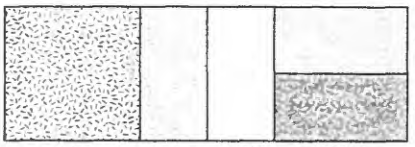
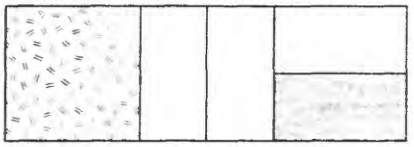
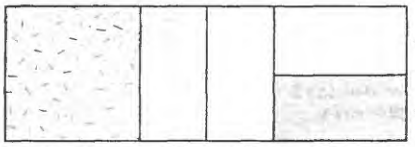


316 +5 +3 322 +3 +5

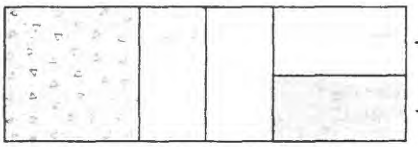
IGNEOUS AND METAMORPHIC PATTERNS



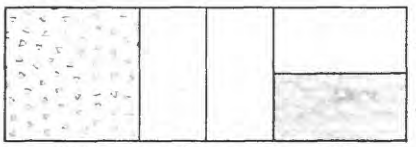
314 +5 +3 321



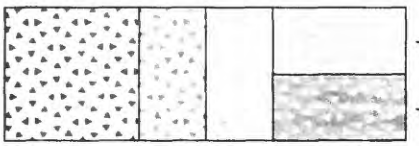
301A +5 +3 307A



401A +5 +3 407A

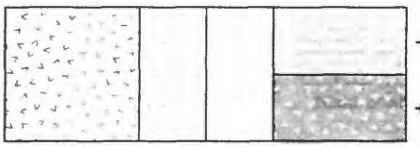


401 +5 +3 407

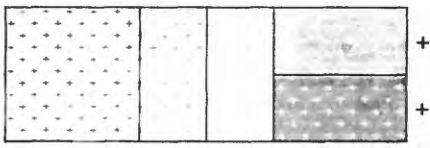


402 +5 +3 408

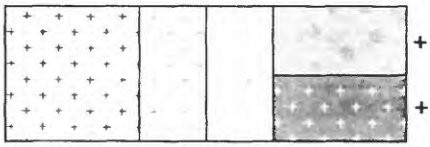
403 +5 +3 409



317 +5 +3 323

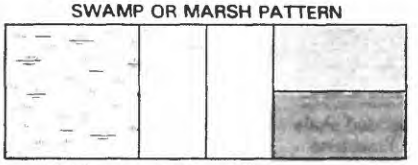


327A +5 +3 332A



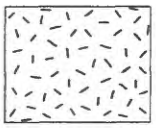
327 +5 +3 332

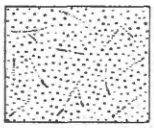
SWAMP OR MARSH PATTERN

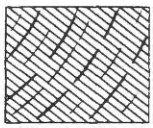


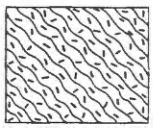
414 +5 +3

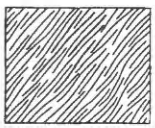
METAMORPHIC LITHOLOGY PATTERNS

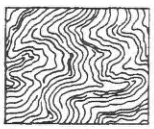

Metamorphism (may be combined with sedimentary and igneous patterns)

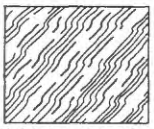

Quartzite

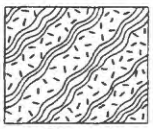

Slate

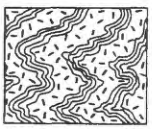

Schistose or gneissoid granite

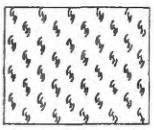

Schist


Contorted schist

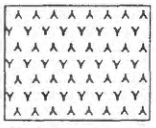

Schist and gneiss

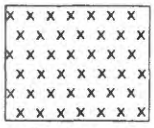

Gneiss

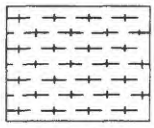

Contorted gneiss

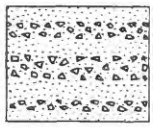

Soapstone, talc, and serpentine

IGNEOUS AND VEIN MATTER LITHOLOGY PATTERNS

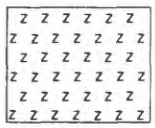

Tuffaceous rock


Crystal tuff

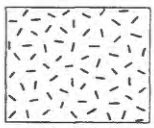

Devitrified tuff

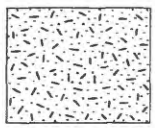

Volcanic breccia and tuff

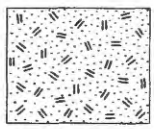

Volcanic breccia or agglomerate

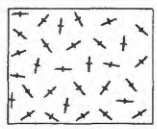

Zeolitic rock

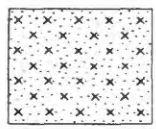

Basaltic flows

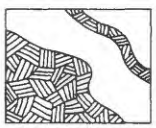

Granite

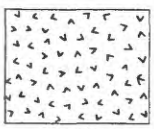

Granite

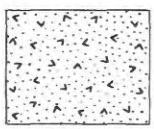

Massive igneous rock

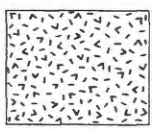

Massive igneous rock

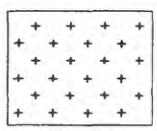

Massive igneous rock

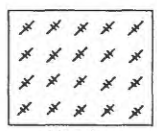

Massive igneous rock

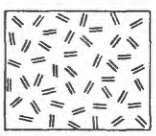

Massive igneous rock

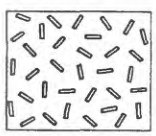

Massive igneous rock

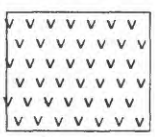

Massive igneous rock

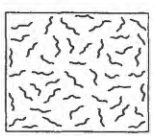

Massive igneous rock

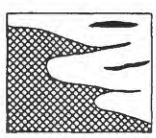

Massive igneous rock


Porphyritic rock


Porphyritic rock


Vitrophyre


Quartz


Ore (solid color in thin areas)