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AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona
April 25, 1968

TO: Mr. W. E. Saegart

FROM: J. D. Sell and N. P. Whaley

GUIDELINES FOR THE USE OF COLOR, SYMBOLS, AND ABBREVIATIONS IN MAPPING, NOTES, AND CORE LOGGING.

Dear sir:

Your request for a presentation on the subject area is hereby submitted in the following memorandum.

The purpose of the memorandum is to present various guidelines and suggestions for recording observed and interpreted field data, with the belief that some standardization will enhance communication among the observer and the recipients.

Information contained in the memorandum was derived from numerous sources, many of which are listed in the Reference Section. Bob Limon of the Mission unit aided in the compilation and John Kinnison of the Tucson office critically reviewed the manuscript.

James D. Sell

Norman P. Whaley

Norman P. Whaley

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona
April 25, 1968

MEMORANDUM

GUIDELINES FOR THE USE OF COLOR, SYMBOLS, AND ABBREVIATIONS IN MAPPING, NOTES, AND CORE LOGGING.

The memorandum and attachments which follow present various guidelines and suggestions, primarily for the field geologist, as an aid in the standardization of recording observed and interpreted data. Standardization of presentation enhances communication between individuals, reduces revision time during compilation, and helps eliminate ambiguities and possible errors between the field and final submittal of the data.

Each geologic map or drill log has its own problems to be solved, as best as possible with the material available, and with the least confusion to both the observer and ultimate reader. The prime function of the geologist is the observation of factual data while the prime function of most maps is to legibly convey the information.

The presentation is divided into four sections: 1) color selection, 2) mapping symbols, 3) abbreviations, and 4) selected references.

Section One - COLOR SELECTION

A basic principle in color selection is the word "flexibility". This implies an ability to impart clarity to a work, and produce a product requiring a minimum of office revision.

Field mapping, using the limited number of pencils normally carried in a clip-board mapping folder, requires flexibility to cover a variety of problems. Problems in the same project area might change as activity progresses from reconnaissance field mapping to detailed field mapping-to detailed prospect or mine mapping-or to alteration studies. Likewise, one area may be composed of mainly sedimentary strata, another of multiple intrusives, and another of a thick sequence of volcanics.

Guidelines for approaching these problems with the equipment available in the usual 8 1/2" x 11" sheet-size folder are discussed below.

The mapping case generally contains ten or more pencil slots which can be effectively filled with the following group (numbers refer to the Eagle Verithin pencils, but similar colors are available from a number of companies):

1. 4H pencil
2. 6H pencil
3. Carmine red (745)
4. Ultramarine (740)
5. True green (751)
6. Lemon yellow (735 1/2)
7. Orange (737)
8. Scarlet red (744)
9. Sienna brown (746)
10. Violet (742)

Any remaining spaces on the individual clip-board could be filled with the following colors: rose (743 1/2), vermilion (750), olive green (739 1/2), sky blue (740 1/2), and tuscan red (746 1/2). Detailed mapping of a given area will often require a unique assortment of colors, and substitution can certainly be made in this suggested set.

A study of the color charts of Attachment A and Attachment B disclose certain similarities:

1. In the formational chart for rock units (Attachment A) the sedimentary sequence changes from grey (Precambrian) to brown, through blue to green, and into yellow (Quaternary) for successively younger units. The orange-reds tend to reflect intrusive rock units while the purples represent the extrusive volcanic rocks.

In mapping an area where an appreciable interval of geologic time is represented by known formational units, the color selection should largely follow the guidelines shown on Attachment A. If this is done, the relative ages of rocks will be depicted by a color sequence wherein grey-brown will represent rocks older than those colored blue-green, and those colored blue-green will represent rocks older than those colored yellow. No problem arises if the units are limited in number and separated by sufficient geologic age; but flexibility must be employed in areas where many rock units occupy the same time (or color) interval. For example, an area contains a Pennsylvanian sedimentary unit, three Permian sedimentary units, and a Cretaceous sedimentary unit, --how is the color separation handled? The Pennsylvanian unit could be assigned the sky blue color ordinarily assigned to the Mississippian, the lower sequence of the Permian a light shading of the ultramarine blue of the Pennsylvania, the middle sequence of the Permian a normal shading of the ultramarine blue with an overlay of black pattern, the upper sequence of the Permian the sea green of the true Permian, and the overlying Cretaceous its assigned color. A clear explanation of colors and unit desigation is essential to any map, but the above example illustrates how a chromatic progression from light blue to more intense blue and to the dark green could be used to indicate the relative ages of these units.

2. At first glance the color chart for individual rock types (attachment B) appears to be an arbitrary assignment of color to rock type, but comparison with the formational chart for rock units brings out a number of similarities: the browns are used for arkose, sandstone, and quartzite (as most often found in the Precambrian to lower Paleozoic sediments); the blues for limestone, dolomite, and associated

shale (as found in the extensive marine sedimentation of the Paleozoic); the greens for shale, schist, and metavolcanics (as found in much of the Cretaceous); the orange-reds for the deep-seated intrusive rocks, and the red purples for the intrusive-extrusive volcanic rocks (as often found in the Cretaceous-Tertiary); the purples for the late extrusive rocks (Quaternary); and the yellows for the young sedimentary units of sand and gravel (Tertiary-Quaternary).

In mapping an area, where outcropping rocks may be varied in type but represent a limited interval of geologic time, this suggested chart usually can more strikingly portray the relationships than can shade variations of the few colors which may represent that interval on the formational chart. For example, if an area contains a sequence of late Tertiary conglomerates and sandy limestones interbedded with rhyolite and andesite the chart for rock types provides a distinct and contrasting color for each of these. The chart of formational rock units provides an essentially similar selection of colors for the volcanics, but offers only one color for both of the sedimentary rock types.

3. In the chart showing degree of alteration-mineralization (Attachment C) there is a chromatic progression from green (fresh), through orange (weak to moderate), to red (moderate to strong). A rapid appraisal of any alteration map would immediately indicate the overall alteration-mineralization configuration and interpreted intensity.

A small brochure by William & Heintz Map Corporation discusses geologic colors as follows:

> "When the color guide is complete we may now proceed to select colors for printing the map which brings us to the whole purpose of this publication.-The use of this workbook for selecting colors. In selecting colors for a complex map we advise, following the U.S.G.S. convention for this usually produces a very pleasing map with nice blending colors. However, there are many instances where this system may not be used, in fact the U.S.G.S. itself does not always follow these conventions. A typical example would be a map in which all the rocks were of the same age. It would be silly to print them all in shades of the same color. So one need not be hide-bound by these conventions, but they serve as a broad guide for preparing a very complex map which covers a wide band of geologic time.
>
> Briefly they are as follows:
>
> Quaternary - yellow
> Tertiary - orange
> Cretaceous - green
> Jurassic-Triassic-Permian - bluish green
> Pennsylvanian - blue

Carboniferous - slate blue
Devonian - bluish purple
Silurian - reddish purple
Ordovician - pink
Cambrian - tan
Precambrian - brown
Volcanic rocks, dikes, or veins - red

In addition line rulings are used for sedimentary rocks, stipples are used for surficial deposits or crystalline rocks and crosshatch patterns for igneous rocks. Solid colors may be used for any kind.

In selecting the colors for a map one should always be guided by the size of the areas of the formation and the color selected for the adjacent formation. So we should pick pastel colors and open patterns for those formations which cover large areas of the map while the strong colors and tight patterns should be used on small areas of narrow bands. In this way we build emphasis and balance. To assist in contrast while maintaining the same general color, alternate bands of the same age should be alternated between solid colors and patterns..."

As noted in the above quote, a variety of additions to the same color can be made with stippling, line ruling and cross-hatching.

Mineralization and structure are two elements that are of particular interest in economic geology. They can be clearly portrayed as follows: Reserve carmine red (745) for depicting mineralized veins and general mineralization, (such as pyrite and low-grade material) and use a sharp, dark line of ultramarine blue (740) for faults. For detailing specific ore distribution (such as chalcopyrite or bornite) in a general mineralization pattern the combination of a light base of ultramarine blue overlain by carmine red produces a distinctive purplish coloration. Finally, the use of a well-pointed 6H pencil as an overlay to both reds and blues "sharpens" the effect of these colors on narrow vein and fault structures.

The paper by Bailey Willis (U.S.G.S.-PP 71), listed in the selected references, discussed the problems of color designation. Additional ideas can often be derived from reviewing various maps which contain units similar to those which the given mapping problem contains. Almost always reference work can help in formulating a color-pattern sequence.

Section Two - MAPPING SYMBOLS

A vast number of symbols have been in use and nearly all geology text books have a page of representative symbols. Attachment D is a copy of the symbols published by the AGI, where Lefax-size sheets are available for purchase. Symbols are often used in logging drill-hole data where, graphically, a great deal of information can be presented in a limited space. The quarterly "Examination of Well Cuttings" by J. W. Low (see list of selected references), although intended mainly for the petroleum geologist, discusses the subject thoroughly and offers many symbol suggestions.

Section Three - SELECTED ABBREVIATIONS

Attachment E is a list of abbreviations commonly used in field notes, diamond drill core logs, informal memorandums, etc. While these abbreviations are not specifically intended for use in maps, they could certainly be used freely on the field map. A complete or finished map should be edited or "cleaned up" to comply as nearly as is possible with the letter symbolization of the U.S.G.S. and the Instituto de Geologia (of Mexico).

The following paragraphs are quoted from "Suggestions to Authors of the Reports of the United States Geological Survey", fifth edition, and express the basic traditions followed when known formations are mapped.

"The standard letter symbols used... consist of a capital letter, indicating the system, and one or more lowercased letters designating the formation and member where used. The letter symbols for the systemic terms are as follows:

Q	Quaternary	M	Mississippian
T	Tertiary	D	Devonian
K	Cretaceous	S	Silurian
J	Jurassic	O	Ordivician
₮	Triassic	€	Cambrian
P	Permian	p€	Precambrian
IP	Pennsylvanian		

The letter symbol C should be used to designate the Carboniferous systems in regions where the Pennsylvanian and Mississippian systems are not differentiated.

The second letter of the symbol is generally the first letter of the formation name, as in Tc for Calvert formation of Tertiary age. If a formation is made of two words--for example, Fort Union formation--there is a choice of symbols, in this instance Tf or Tfu. If members of the Fort Union are mapped, the first letter of the name is commonly used with the first letter of the member name, as in Tfl for the Lebo shale member of the Fort Union formation. This method keeps the symbol from becoming unnecessarily long. Do not use complex multiple letter symbols. No symbol should include more than four letters.

For a mapped unit of Precambrian age that does not bear a formal name but is referred to only by rock type, as for example, gneiss, the symbol may consist of the first two letters of the rock type. The letter symbol for the rock type need not be preceeded by the age symbol.

On maps showing metamorphic rocks, where it may be desirable to show the metamorphic zones or facies involved in the various stratigraphic units, a letter symbol may be used to indicate the type of zone or facies. The letter symbol and the boundaries of the zone or facies may be over-printed on the map in a color differing from that used for the formation symbols and boundaries."

Abbreviations should be used with discretion - particularly when an extensive text is involved. Do not attempt to compose a number of consecutive sentences or rock descriptions consisting of abbreviations only. They are easy to put on paper, by a writer thoroughly familiar with such abbreviations, but translation by another person, if not subject to ambiguity, is exceedingly difficult.

All abbreviations retained in a final text or on a finished map should be explained in the same manner as color designation and symbols.

Section Four - SELECTED REFERENCES

The following list goes into the above subjects in greater detail and could be reviewed for both pleasure and academic interest.

Text Material

American Geologic Institute (AGI), 1950's
Various data sheets pertaining to geology.
Presently in excess of forty sheets: AGI,
1444 N. Street, N. W., Washington, D. C. 20005

Ballard, Thomas J., and Conklin, Quentin E., 1955, The Uranium Prospector's Guide: Harper and Brothers, New York, 251 p.
See Especially

Chapter 2. Maps by Ambrose Shea, PP. 13-32.

Forrester, J. D., 1946, Principles of Field and Mining Geology: John Wiley and Sons, New York, 647 p.
See Especially

Chapter V	Field Equipment Exclusive of Surveying Instruments, PP. 180-192
Chapter VI	General Survey Procedures, PP. 193-253
Chapter VII	Survey Methods and Instruments, PP. 254-329.
Chapter VIII	Surveying and Mapping Proceedures, PP. 333-348
Chapter XII	Library and Laboratory Research and the Preparation of Maps, Models, and Illustrations, PP. 445-474.

Goddard, E. N., Chairman, 1947, New List of Geologic Map Symbols prepared by Map Symbol Committee: U. S. Geol. Survey Special Publication, Washington, D. C. 6, sheets.

Lahee, F. H., 1952, Field Geology, fifth edition; McGraw-Hill Book Company, New York, 883 p.
See Especially

Chapter 15 through 21, PP. 424-720

Chapter 19	Modes of Geologic Illustration PP. 615-690.

Leroy, L. W., 1951, Subsurface Geologic Methods (A Symposium), Second edition; Colorado School of Mines, Golden, Colorado, 1167 p.
See Especially

Chapter 10	Graphic Representation (Leroy, L. W.) PP. 856-893.
Chapter 11	Subsurface Methods and Illustrations (Low, J. W.), PP. 894-968.

Chapter 12 — Subsurface Methods as Applied to Mining Geology (Kuhn, T. H.), PP. 969-988.

Chapter 13 — Subsurface and Office Representation in Mining Geology (Herness, S. K.), PP. 989-1037.

Low, Julian W., 1951, Examination of Well Cuttings: Quarterly of the Colorado School of Mines, Golden Colorado, Vol 46, No. 4, 48 p.

Low, Julian W., 1952, Plane Table Mapping: Harper and Brothers, New York, 365 p.
See Especially

Chapter XII — Methods and Practices in Map Construction, PP. 293-325.

McKinstry, Hugh E., 1948, Mining Geology: Prentice-Hall Inc., New York, 680 p.
See Especially

Chapter 1 — Geologic Mapping, PP. 1-34.

Chapter 6 — Correlating Data, PP. 162-198.

Chapter 16 — Field Exploration, PP. 407-427.

Ridgeway, John L., 1920, The Preparation of Illustrations for Reports of the U. S. Geologic Survey: U.S.G.S. Administrative Publication, Superintendent of Documents, Washington, D. C. 101 p.

Schmitt, Harrison, 1932, Cartography for Mining Geology: Economic Geology, Vol. 27, No. 8, PP. 716-736.

William & Heintz, 1965, The Preparation of Copy for Geologic Maps: Brochure of William & Heintz Map Corporation, Washington, D.C. 20027, 7 p.

Willis, Bailey, 1912, Index to the Stratigraphy of North America (accompanied by a Geologic Map of North America): U.S.G.S. Professional Paper No. 71, 894 p.
See Especially

Chapter 1 — Section 4. Geologic Division Mapped, PP. 7-20.

Chapter 1 — Section 6. Color Scheme with Subtitles of Principles, Usages, and Principles for Coloring Geological Maps, PP. 21-30.

Map Materials

Arizona Highway Geologic Map, by M. E. Cooley, 1967: Arizona Geological Society, Tucson, 1 sheet.

Carta Geologica de la Republica Mexicana, by M. R. Fierro, 1956: XX International Geological Congress, Mexico, 2 sheets.

Geological Map of California, P. Jenkins Series, 1958: California Division of Mines and Geology, San Francisco, 25 sheets printed, 2 in press.

Geological Map of North America, by G. W. Stose, 1965: Published by the Geological Society of America, Denver, Colorado, 2 sheets.

Geological Map of the United States, by G. W. Stose, 1960: U. S. Geological Survey, Washington, D. C., 4 sheets.

Various maps in the Bulletins and Professional Papers of the U. S. Geological Survey.

LETTER SYMBOLS AND SUGGESTED COLOR CHART

(NUMBERS REFER TO

SEDIMENTARY ROCKS

Q— 735 ½
Quaternary rock materials

Ts 736 Dark
Tertiary sedimentary rocks

739 ½ Dark
Tertiary - Cretaceous sedimentary rocks

Ks 739 Dark
Cretaceous sedimentary rocks

Js 751
Jurassic sedimentary rocks

Rs 738 ½
Triassic sedimentary rocks

Ps 737 ½
Permian sedimentary rocks

IPs 740
Pennsylvanian sedimentary rocks

Ms 740 ½
Mississippian sedimentary rocks

Ds 741
Devonian sedimentary rocks

Ss 741 ½
Silurian sedimentary rocks

Os 760
Ordovician sedimentary rocks

€s 746
Cambrian sedimentary rocks

p€s 734 ½
Precambrian sedimentary rocks

IGNEOUS ROC

EXTRUSIVE

742
Quaternary - Tertiary volcanic rocks

Tv 743 ½ Light
Tertiary volcanic rocks

LARAMIDE OROGENY {

737
Tertiary - Cretaceous volcanic rocks TERTIA

738
Cretaceous volcanic rocks

746 ½
Mesozoic volcanic rocks (undifferentiated) ME {

ROCK UNITS WHEN FORMATION IS SHOWN

(ERITHIN PENCILS)

OCKS

INTRUSIVE

750 Dark

Cretaceous intrusive rocks

743 ½

sozoic intrusive rocks (undifferentiated)

pCg 755

cambrian "granites"

METAMORPHIC ROCKS

TKm 739 ½ Light

Tertiary - Cretaceous metamorphic rocks

744

Mesozoic metamorphic rocks (undifferentiated)

747

Precambrian gneiss (n) and schist (s)

SUGGESTED COLOR CHART FOR ROCK TYPES — GEOLOGICAL MAPPING WHEN FORMATION IS NOT SHOWN

(NUMBERS REFER TO EAGLE VERITHIN PENCILS)

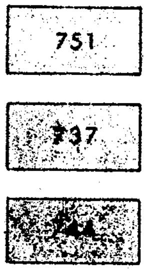
Pencil	Rock type
735 ½	Alluvium
757 LIGHT	Alaskite
[illegible]	Andesite
736 DARK	Aplite
[illegible]	Argillite
[illegible]	Arkose
742	Basalt
[illegible]	Calcareous shale
735	Conglomerate
[illegible]	Dacite
[illegible] LIGHT	Diabase
[illegible]	Diorite
[illegible]	Dolomite
741	Dolomitic limestone
[illegible]	Felsite
735 ½ DARK	Fill, dumps, etc (symbol optional)
741 ½	Fossiliferous limestone
738 ½	Gneiss
755	Granite
[illegible]	Granodiorite
[illegible]	Lamprophyre
743 ½ LIGHT	Latite
740 ½	Limestone
751 DARK	Metasediments
738	Metavolcanics
737	Monzonite
[illegible]	Obsidian, Pitchstone, Perlite, Pumice
736 LIGHT	Pegmatite
750 LIGHT	Qtz diorite
[illegible]	Quartzite
[illegible]	Qtz latite
736 ½ LIGHT	Qtz. monzonite
743 DARK	Rhyolite
[illegible]	Sandstone
740	Sandy limestone
[illegible]	Schist
751 LIGHT	Shale
756 LIGHT	Silt, Mud, Grit, etc.
757 DARK	Syenite
743 LIGHT	Trachyte
734 ½	Tuff
744	Ultrabasics and Gabbro

ALTERATION – MINERALIZATION

(NUMBERS REFER TO EAGLE VERITHIN PENCILS).

SMALL SCALE

– where only
DEGREE of ALTERATION-MINERALIZATION
is shown

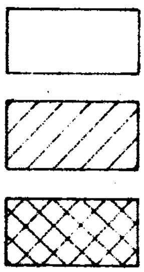


FRESH

WEAK to MODERATE

MODERATE to STRONG

– If color is not desired
the following patterns could be used:



FRESH

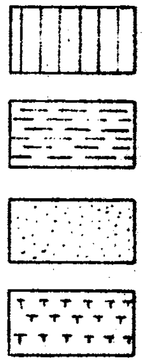
WEAK to MODERATE

MODERATE to STRONG

With either of the above systems the TYPE OF ALTERATION-MINERALIZATION could be described in the explanation or title of the map

LARGE SCALE

– where
TYPE of ALTERATION-MINERALIZATION
is shown by symbol



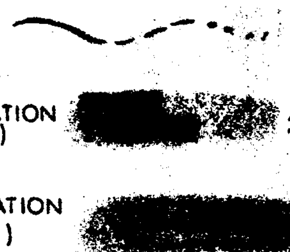
ARGILLIC

SERICITIC

SILICIFICATION

TACTITE

FAULTS AND MINERALIZATION



FAULT (740)

MINERALIZATION (General) (745)

MINERALIZATION (Specific) (745 over 740 Base)

GEOLOGIC MAP SYMBOLS-I

A data sheet listing map symbols commonly used in the preparation of geologic maps, compiled principally from published lists of the U. S. Geological Survey, Map Symbol Committee and recently published geologic maps.

BEDDING

Strike and dip of beds

Horizontal beds

Approximate strike and dip

Strike of vertical beds

Strike and dip where upper bed can be distinguished, used only in areas of complex overturned folding

Strike and dip of overturned beds

Generalized strike and dip of crumpled, plicated crenulated, or undulating beds

Strike and dip of beds and plunge of slickensides

Apparent dip

FOLIATION AND CLEAVAGE

Strike and dip of foliation

Strike and dip of cleavage

Strike of vertical foliation

Strike of vertical cleavage

Strike of horizontal foliation

Horizontal cleavage

Alternative symbols for other planar elements

The map explanation should always specify the type of cleavage mapped

January 1958

Additional copies of this data sheet may be obtained from the AMERICAN GEOLOGICAL INSTITUTE, Cost $0.10.

LINEATIONS

Bearing and plunge of lineation

Vertical lineation

Horizontal lineation

Double lineation

Strike and dip of beds and plunge of lineation

Strike and dip of foliation and plunge of lineation

Strike and dip of beds showing horizontal lineation

Strike and dip of foliation showing horizontal lineation

Vertical beds, showing plunge of lineation

Vertical foliation, showing plunge of lineation

Vertical beds, showing horizontal lineation

Vertical foliation, showing horizontal lineation

Strike and dip of beds, showing rake of lineation

Strike and dip of foliation showing rake of lineation

Generalized strike of folded beds, or foliation, showing plunge of fold axes.

JOINTS

Strike and dip of joint

Strike of vertical joint

Horizontal joint

Strike and dips of multiple systems

AGI 2

GEOLOGIC MAP SYMBOLS-2

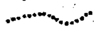
A data sheet listing map symbols commonly used in the preparation of geologic maps, compiled principally from published lists of the U. S. Geological Survey, Map Symbol Committee and recently published geologic maps.

CONTACTS

Definite contact

Approximate contact

Inferred contact



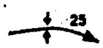
Concealed contact

Contact, showing dip

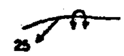
Vertical contact

FOLDS

Anticline, showing trace of axial plane and bearing and plunge of axis



Syncline, showing trace of axial plane and bearing and plunge of axis

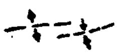


Overturned anticline, showing trace of axial plane, direction of dip of limbs, and bearing and plunge of axis

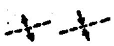
Overturned syncline, showing trace of axial plane and direction of dip of limbs

Plunge of minor anticline, showing degree of plunge

Plunge of minor syncline, showing degree of plunge

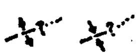


Approximate axis

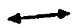


Inferred axis

Concealed axis



Doubtful axis, dotted where concealed



Horizontal fold axes

Dome

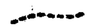
Fold with inclined axial plane, showing dip and bearing of plane and plunge of axis

FAULTS

Fault, showing dip

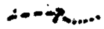
Vertical fault

Approximate fault



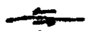
Inferred fault

Concealed fault

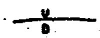


Doubtful fault, dotted where concealed

Normal fault, hachures on down side



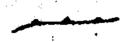
Fault, showing relative movement



High angle fault, movement—U, up, and D, down

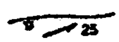
Thrust or low angle reverse faults, T, upper plate

Normal fault, showing bearing and plunge of relative movement of downthrown (D) block



Thrust or reverse fault, barbs on side of upper plate

Fault, showing bearing and plunge of grooves, striations, or slickensides



Reverse fault, showing bearing and plunge of relative movement of downthrown (D) block

Lineaments

Fault zone or shear zone, showing dip

Fault breccia

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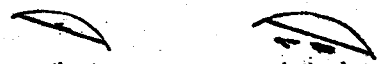
AGI 3

GEOLOGIC MAP SYMBOLS-3

A data sheet listing map symbols commonly used in the preparation of geologic maps, compiled principally from published lists of the U. S. Geological Survey, Map Symbol Committee and recently published geologic maps.

CROSS SECTIONS



overthrust *underthrust*

Low angle fault

normal fault *vertical* *reverse fault*

High angle fault

A, *movement away* T, *movement toward*

Horizontal movement in tear or shear fault

Klippe Fenster or window

OIL & GAS WELLS

Well location Dry hole

Oil well Oil and gas well Gas well

Oil well, with show of gas Gas well, with show of oil

Dry hole, with show of oil Dry hole, with show of gas

Dry hole, with show of oil and gas

Abandoned oil well Abandoned gas well

Abandoned oil and gas well

Abandoned oil well, with show of gas Abandoned gas well, with show of oil

Shut in well

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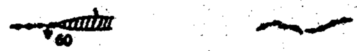
MINERAL DEPOSITS & MINE WORKINGS

SURFACE MAPPING



Vein, showing dip Stringers or veinlets

Altered wall rock showing gradational alteration

Mine, quarry, glory hole Sand, gravel or clay pit

Vertical shaft Inclined shaft

Portal of tunnel or adit

Trench

Portal and open cut Prospect pit or open cut

Dump

Vertical drill hole

80

Inclined drill hole, showing bearing and inclination

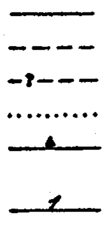
AGI 20

FAULT SYMBOLS

by Mason L. Hill

<u>INTRODUCTION</u>: The following fault symbols are designed to remove the ambiguity resulting from failure of traditional symbols to distinguish between fault <u>slip</u> and fault <u>separation</u>. Where a linear geologic element is displaced the <u>actual</u> relative movement (slip) can be determined (e.g., displaced intersection of dike and bed). Generally, however, where a tabular geologic element is displaced only <u>apparent</u> relative movement (separation) can be determined. Thus, for example, these symbols provide for the important distinction between normal fault (only separation known) and normal slip fault (slip known). Refer to "Dual Classification of Faults," Mason L. Hill (1959), A.A.P.G. Bull., v. 43, p. 217-21.

General Symbols



Fault trace, for maps and sections.

Approximately located trace, for maps and sections.

Conjectural trace, for maps and sections.

Concealed map trace; Conjectural (. . ? . .).

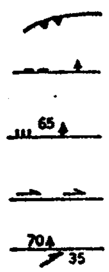
Dip direction; Amount (▲60), approximate amount (▲25±), conjectural direction (▲?).

Relative slip direction; Conjectural (?←); Slip plunge (▲), approximate plunge (25±).

Note: Fault trace may be distinguished from other geologic contacts by weight or color of line, or by labeling with name or symbol, as desired. Slip plunge is vertical angle measured downward from horizontal to net slip.

Slip Symbols for Maps

(Add direction and amount of dip, direction of relative slip, and slip plunge, if and where known.)



Thrust slip fault. Triangles on relatively overthrust block; Fault dips $< 45°$

Reverse slip fault. Rectangles on relatively elevated hanging wall block; Fault dips $> 45°$ Dip direction is shown here.

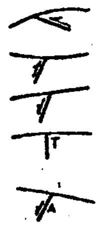
Normal slip fault. Barbs on relatively depressed hanging wall block; Fault dip and direction of relative slip are shown here.

Right-lateral slip fault. Arrows shown sidewise relative movement of block opposite the observer.

Left-lateral slip fault. Fault dip and slip plunge are shown here. If dip-slip and strike-slip components were nearly equal, the name reverse left-lateral slip fault would be appropriate.

Note: Triangles, rectangles, and barbs may be shown as appropriate and convenient along the map trace of the fault. However, none of these symbols should be used on maps unless some evidence of at least the approximate orientation of slip is obtained.

Slip Symbols for Sections



Thrust slip fault. Arrow shows principal relative movement component; Fault dips $< 45°$.

Reverse slip fault. Fault dips $> 45°$.

Normal slip fault.

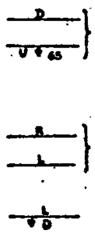
Right-lateral slip fault. Principal relative movement component of block toward observer is shown by the letter T.

Left-lateral slip fault. Letter A (away) and arrow (downward) show relative movement components. If these components are nearly equal, the name *normal* left-lateral slip fault is used.

Note: Single barb arrows and letters (T and A) may be shown on either side of the section trace of the fault, as appropriate and convenient. However, none of these symbols should be used on sections if only separation is determined.

Separation Symbols for Maps

(Add direction and amount of dip, if and where known.)



Dip separation-apparent relative movement in fault dip; D-downthrown or U-upthrown. Normal fault has dip toward downthrown block; Reverse fault has $> 45°$ dip toward upthrown block (Illustrated); Thrust fault has $< 45°$ dip toward overthrown block.

Strike separation - apparent relative movement in fault strike of block opposite the observer. Right-lateral fault, R; Left-lateral fault, L.

Dip and strike separations nearly equal. A normal left-lateral fault is illustrated.

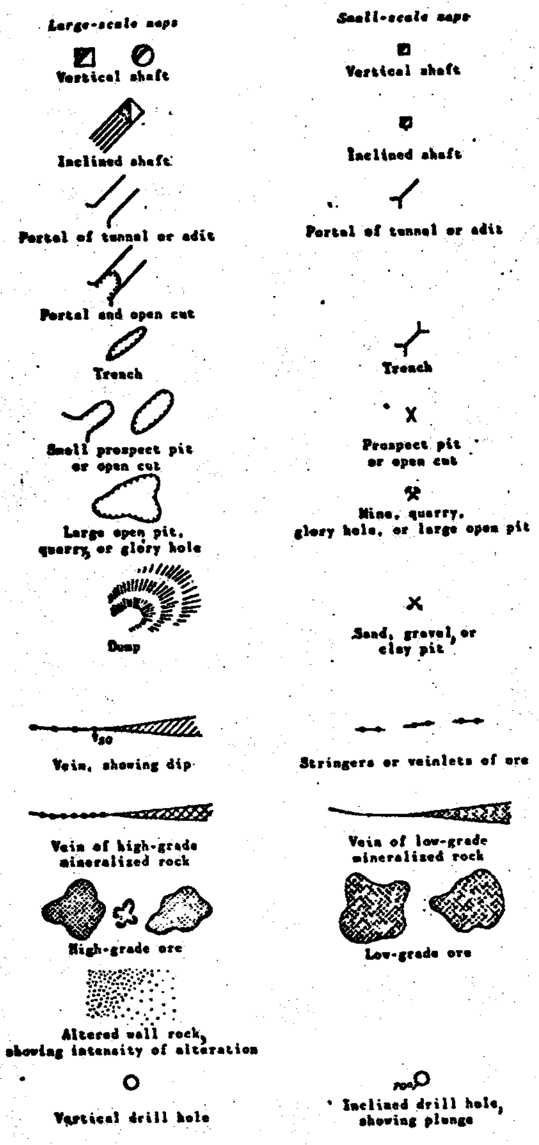
Note: Letters indicating separation may be shown as appropriate and convenient on either side of the fault trace. The symbols (+) and (-) may be substituted for U and D but none represents any component of slip. Separation symbols are not needed for sections, and are only occasionally necessary for maps because the displacement of tabular geologic elements is usually obvious.

<u>REMARKS</u>: The essential function of these proposed fault symbols is to let geologists clearly indicate where information on fault slip has been determined, and not allow them to indicate slip where only separation is known. As customary, only those symbols which are used on a particular geologic illustration need be shown in the legend.

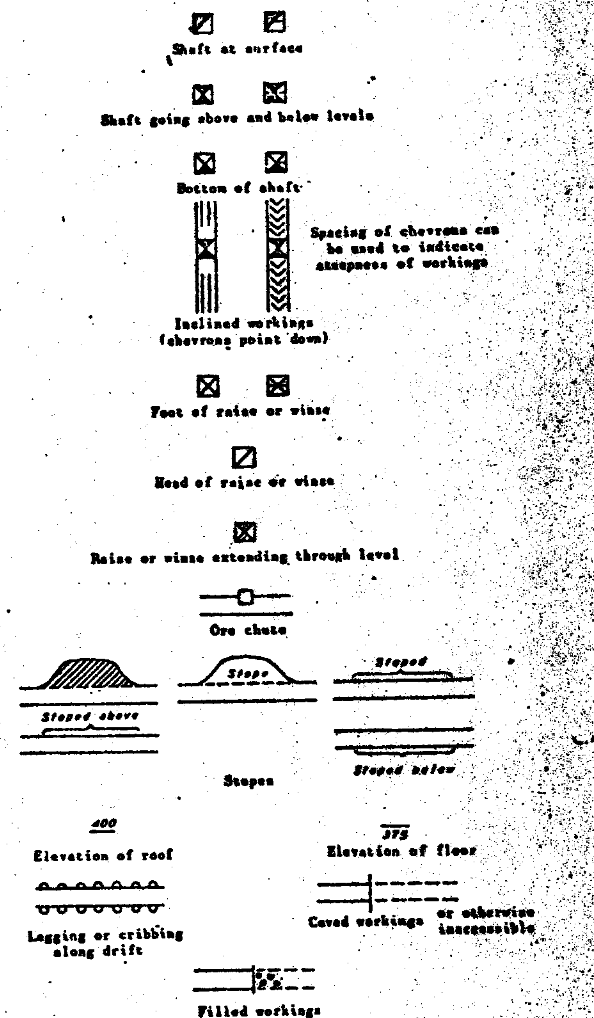
AGI
38

SYMBOLS FOR MINERAL DEPOSITS AND MINE WORKINGS

SURFACE OPENINGS



UNDERGROUND WORKINGS
(horizontal line denotes water filled)



Use standard geological symbols for rock types, faults, folds, contacts, joints, lineations, attitudes, etc. (see Data Sheets No. 1, 2, 3, and 20).

Additional copies of this data sheet may be obtained from the AMERICAN GEOLOGICAL INSTITUTE, Cost $0.50.

AGI
23a

DESCRIPTIVE MODAL CLASSIFICATION OF IGNEOUS ROCKS

by Donald W. Peterson

The classification of Table 1 shows the names most commonly applied to igneous rocks. It represents a limited consensus on usage of the terms, and it is intended simply to be an aid in naming the more common igneous rocks. The classification is not intended to supersede other schemes, nor to replace schemes with other purposes. Neither does it represent any effort at dictating a standard or universal scheme of rock classification. Table 2 is an expansion of the lower right hand part of Table 1.

Most of the names shown are based on grain size and relative abundance of quartz and feldspars. The approximate color index and range of the An content of plagioclase are given below the rock names. Color index is a supplementary rather than an essential criterion in naming the rocks. The plagioclase An content is needed only for identification of modal albite, in distinguishing between the diorite and gabbro clans, and in recognition of eucrite, allivalite, and harrisite on Table 2; for other rocks it is supplementary. Ideally, the distinction between the diorite and gabbro clans is based on both color index and plagioclase composition; however, where these criteria conflict either may be used, depending on geologic circumstances, affinities of the rock, and judgment of the investigator.

Because the names are based on volume percent of minerals, most can be applied accurately only after laboratory study. They can be used in the field with moderate accuracy by omitting plagioclase composition as a definitive criterion and by placing more reliance on the approximate color index.

Because names of fine-grained rocks are generally based on composition and amounts of phenocrysts, they may not accurately represent the bulk composition of the rock, and correlation between fine- and coarse-grained members of a clan should be regarded as rather loose. Distinctions between fine-grained rocks are rather indefinite, and the boundaries are shown on the chart as dashed lines.

The definitions of the following common rocks depend largely on texture or occurrence.

APLITE—A dike rock consisting almost entirely of quartz and feldspar and having a characteristic fine-grained sugary texture. The name sometimes implies granite aplite, but aplites of other composition are common.

LAMPROPHYRE—A group name for dark, porphyritic to panidiomorphic dike rocks that contain abundant euhedral mafic minerals, commonly of two generations; generally feldspars are restricted to the groundmass, and some lamprophyres lack feldspars. Lamprophyres range from syenitic to gabbroic and are transitional into ultramafic; they commonly are alkalic.

PEGMATITE—Holocrystalline rocks that are at least in part very coarse grained, whose major constituents include minerals typically found in ordinary igneous rocks, and in which extreme textural variations, especially in grain size, are characteristic. (Jahns, R. H., 1955, Econ. Geol. 50th Anniv. Vol., pt. II, p. 1030).

PORPHYRY—Two widely divergent definitions are in common use:

1) A hypabyssal rock containing phenocrysts. "Granite porphyry," etc. imply that phenocrysts are set in a fine-grained phaneritic matrix; "rhyolite porphyry," etc. imply that phenocrysts are set in an aphanitic matrix. Long and common usage gives authority to this definition, although certain inconsistencies are apparent, and names that depend on occurrence (hypabyssal) are undesirable. According to this definition, extrusive and plutonic rocks should never be called "porphyry," but instead be described as "porphyritic."

2) Any porphyritic rock with more than a certain minimum amount of phenocrysts (10%, 12%, 50%, or "abundant" are advocated by various authors). Proponents logically claim that a rock name should be valid regardless of mode of occurrence of the rock, but this definition is contrary to much common usage.

This chart, being a consensus, tolerates either definition, but urges that to avoid confusion and controversy, the name "porphyry" be used only when absolutely necessary, and then be restricted to porphyritic hypabyssal rocks.

TABLE 1

DESCRIPTIVE CLASSIFICATION OF IGNEOUS ROCKS

1 2	Alkalic feldspar[3] >2/3 total feldspar	Alkalic feldspar[3] 1/3 to 2/3 total feldspar	Plagioclase 2/3 to 9/10 total feldspar	Plagioclase >9/10 total feldspar: An <50	Plagioclase >9/10 total feldspar: An >50	Feldspar <10%
	Color index (CI) 0–20±[4]	Color index (CI) 10–40[4]			Color index (CI) 40–70[4]	Color index (CI) >70[4]
Quartz >10%	*RHYOLITE*	*DELLENITE ≡ QUARTZ LATITE*	*RHYODACITE*	*DACITE*	*QUARTZ BASALT*[5]	Extremely rare
	GRANITE CI 5–15 An 0–15	ADAMELLITE ≡ QUARTZ MONZONITE CI 10–20 An 12–33	GRANODIORITE CI 15–30 An 25–40	TONALITE ≡ QUARTZ DIORITE CI 25–40 An 35–50	QUARTZ GABBRO[5] CI 40–70 An 50–90	
	ALASKITE CI <5 An 0–35			TRONDHJEMITE CI <10 An 15–30		
Quartz <10% Feldspathoids <10%	*TRACHYTE*	*LATITE*	*ANDESITE*		*BASALT*	PERIDOTITE Pyroxene and olivine
					DIABASE (≡ DOLERITE)	PERKNITE Pyroxene and/or amphibole
	SYENITE CI 5–25 An 0–30	MONZONITE CI 20–35 An 25–45	DIORITE CI 25–40 An 35–50		GABBRO CI 40–70 An 50–100	DUNITE Olivine
Feldspathoids >10%	*PHONOLITE*	*FELDSPATHOIDAL LATITE*	*FELDSPATHOIDAL ANDESITE*		*FELDSPATHOIDAL BASALT*	Great variety of uncommon rocks
	FELDSPATHOIDAL SYENITE Includes many varieties of uncommon rocks	FELDSPATHOIDAL MONZONITE Rare	FELDSPATHOIDAL DIORITE Rare		FELDSPATHOIDAL AND ALKALIC GABBRO Includes many varieties of uncommon rocks	

[1] Fine-grained, commonly volcanic rocks shown in italics; coarse-grained, commonly plutonic rocks in gothic letters; less common rocks of both varieties are in small print. Excepting diabase, names reflecting special textures are not shown, but some of these are defined briefly on the reverse side.
[2] Amounts of minerals based on volume percent.
[3] Includes K-feldspar, perthite, and modal albite (An_0–An_5).
[4] Defined as the total percent of dark minerals (biotite, amphibole, pyroxene, olivine, opaque oxides, etc.).
[5] Quartz basalt and quartz gabbro may be used if quartz exceeds 2 or 3 percent.

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TABLE 2

DESCRIPTIVE CLASSIFICATION OF IGNEOUS ROCKS POOR IN QUARTZ AND ALKALIC FELDSPAR

[1]	Plagioclase >10% of rock	Plagioclase <10% of rock
Pyroxene <10% Olivine <10%	*Hornblende basalt*	*No volcanic equivalents*
	Anorthosite (plagioclase only) CI 0-10 An 50-100 Hornblende gabbro CI 10-90 An 30-80	Hornblendite (hornblende only) CI >90 Biotitite (biotite only) CI >90 Chromitite (chromite only) CI >90
Pyroxene >10% Olivine <10%	*BASALT*	*No volcanic equivalents*
	DIABASE (≡ DOLERITE) (fine grained gabbro with ophitic texture)	PYROXENITE CI >90
	GABBRO (Clinopyroxene dominant) CI 10-90 An 50-100 Norite (orthopyroxene dominant) CI 10-90 An 50-100 Eucrite[2] (both pyroxenes) CI 20-90 An >70	Bronzitite (orthopyroxene dominant) CI >90 Websterite (both pyroxenes) CI >90 Augitite (clinopyroxene dominant) CI >90
Pyroxene >10% Olivine >10%	*OLIVINE BASALT* *Ankaramite* (augite exceeds olivine, low in plagioclase)	*No volcanic equivalents*
	OLIVINE DIABASE	PERIDOTITE CI >90
	OLIVINE GABBRO CI 20-90 An 50-100	Harzburgite ≡ Saxonite (orthopyroxene dominant) CI >90 Lherzolite (both pyroxenes) CI >90 Wehrlite (clinopyroxene dominant) CI >90
Pyroxene <10% Olivine >10%	*PICRITE BASALT ≡ OCEANITE*[3]	*No volcanic equivalents*
	TROCTOLITE CI 10-90 An 50-100 Allivalite (plagioclase dominent) CI 10-50 An >90 Harrisite (olivine dominant) CI 50-90 An >90	Dunite (olivine only) CI >90 Kimberlite ≡ Mica peridotite (olivine and phlogopite) CI >70
Feldspathoids >10%	*FELDSPATHOIDAL BASALT* *Tephrite* (nepheline and/or leucite, no olivine) *Basanite* (olivine tephrite)	*Limburgite* (analcite, augite, olivine, and glass) *Katungite, Ugandite, Mafurite* (melilite, leucite, kalsilite, respectively, with olivine)
	FELDSPATHOIDAL and ALKALIC GABBRO[4] Teschenite (analcite and augite) Theralite (nepheline and augite) and many others	Urtite, Ijolite, Melteigite (nepheline and aegirine, in order of decreasing nepheline) CI 30-70 Fergusite (leucite and augite) CI 30-50 Alnöite (melilite, olivine, and biotite) Uncompahgrite (melilite, pyroxene) and many others

[1] Fine-grained commonly volcanic rocks shown in italics, coarse-grained, commonly plutonic rocks in gothic letters. Family names shown in upper case, less common families in smaller print. Varietal names shown in lower case. The classification is based on the presence or absence of plagioclase and the relative proportions of pyroxene, olivine, and feldspathoids. If further information is essential to the definition, it is indicated in brief notations. Amounts of minerals based on volume percent. Color index (CI) defined as the total volume percent of dark minerals.

[2] Le Bas (1959, Geol. Mag., v. 96, p. 497-502) discusses the widely divergent definitions of "eucrite", and recommends that the term be dropped and replaced by gabbro. Eucrite is included here only because it is frequently used in the literature.

[3] Some picrite basalts and oceanites may contain more than the indicated 10 percent pyroxene. Their essential distinguishing factor is that olivine exceeds pyroxene.

[4] Alkalic gabbros grade into feldspathoidal syenites and monzonites at one end and into ultrabasic rocks on the other. Distinction between types is especially poorly defined.

LIST OF ROCKS NOT ADAPTABLE TO THE CLASSIFICATION CHARTS, AND LAMPROPHYRES

TABLE 3

Bostonite.—Aplitic alkalic syenite, sugary to trachytic texture (the trachytic texture is essential to some classifications, not to others).

Charnockite.—Orthopyroxene-bearing granitic type rock; generally regarded as metamorphic.

Comendite.—Light-colored pantellerite, a sodic rhyolite containing sodic amphibole or pyroxene.

Essexite.—A pyroxene-rich alkalic gabbro with essential nepheline in some usages; with essential alkalic feldspar in others.

Foyaite.—Leucocratic, coarse-grained nepheline syenite

Hyperite.—Used variously as a general name for gabbro, an equivalent for norite, and as a synonym for olivine bearing norite.

Kentallenite.—A dark monzonite, subequal amounts of augite, olivine, orthoclase, and plagioclase.

Keratophyre.—An albitized rock, the intermediate member of the spilite suite; composed of albite and of small amounts of pyroxene and/or amphibole which may be altered to chlorite. Those carrying quartz are called quartz keratophyre, and comprise the siliceous member of the spilite suite.

Liparite.—A synonym of rhyolite not much used in North America.

Malignite.—Mafic feldspathoidal syenite to alkalic gabbro, mainly aegirine augite, nepheline, and orthoclase.

Mugearite.—Variously called oligoclase basalt and olivine-oligoclase andesite; major phenocrysts oligoclase, olivine, and orthoclase, low SiO content, trachytic texture.

Nordmarkite.—Quartz-bearing syenite, chiefly of microperthite.

Pantellerite.—A dark-colored sodic rhyolite with relatively abundant alkalic mafic minerals.

Shonkinite.—Varies from dark syenite to alkalic gabbro, chiefly augite and orthoclase, variable nepheline, olivine, plagioclase, and biotite.

Spilite.—"Spilite suite" is family of igneous rocks rich in Na-plagioclase and low in K feldspar, generally considered to have formed by alteration processes. Spilite is the least siliceous, most calcic member, generally defined as albitized basalt.

Tholeiitic basalt.—Briefly defined as basalt without olivine. Tholeiitic magma is a type of basaltic magma containing little or no olivine, about saturated in silica, and yielding over-saturated late differentiates.

Trachyandesite.—Many divergent definitions; generally used as a synonym of latite.

Trachybasalt.—Many divergent definitions; a possible consensus is a K-rich basalt with plagioclase (An >50).

LAMPROPHYRE

Type of feldspar / Dominant mafic mineral	Feldspar is chiefly alkalic feldspar	Feldspar is chiefly plagioclase	No feldspar
Biotite	MINETTE	KERSANTITE	ALNOITE OUACHITITE
Pyroxene and/or Amphibole	VOGESITE	SPESSARTITE ODINITE	
Alkalic pyroxene and/or Alkalic amphibole	SODIC MINETTE SODIC VOGESITE	CAMPTONITE	MONCHIQUITE FOURCHITE

DESCRIPTIVE CLASSIFICATION OF METAMORPHIC ROCKS[1]

by
Robert R. Compton
Stanford University

EXPLANATION: In this binomial system for naming metamorphic rocks, the main rock name is based on the texture of the rock, while the principal or more significant minerals are added as modifying nouns, as biotite-quartz schist, andalusite-cordierite hornfels. The names are meant to be applied on a descriptive basis; a schistose rock, for example, should not be called a hornfels because it is found in a contact aureole.

TEXTURES

Schistose-- grains platy or elongate and oriented parallel or subparallel, so that rock cleaves readily. Foliated (lepidoblastic) if fabric is planar, lineated (nematoblastic) if linear.

Granoblastic-- grains approximately equidimensional; platy and linear grains oriented randomly or so subordinate that cleavage is not developed.

Hornfelsic-- grains irregular and interincluded but generally microscopic; recognized in field by unusual toughness, ring to hammer blow, and hackly fracture at all angles to bedding. Under hand lens, freshly broken surfaces show a sugary coating that will not rub off (formed by rending of interlocking grains).

Semischistose-- platy or linear grains subparallel but so subordinate or so unevenly distributed that rock has only a crude cleavage; especially common in metamorphosed granular rocks, as sandstones and igneous rocks.

Cataclastic-- clastic textures resulting from breaking and grinding with little if any recrystallization; characterized by angular, lensoid, or rounded fragments (porphyroclasts) in a fine-grained and commonly streaked or layered groundmass. Mortar structure applies to unoriented arrangements, and phacoidal, flaser, and augen structure apply to lenticular arrangements.

ROCK NAMES

Schistose rocks

Schist-- grains can be seen without using a microscope.

Phyllite-- all (or almost all) grains of groundmass microscopic, but cleavage surfaces have sheen caused by reflections from platy or linear minerals.

Slate-- very cleavable but surfaces dull; tougher than shale and cleavage commonly oblique to bedding.

Phyllonite-- appearance like phyllite but formed by cataclasis and recrystallization of coarser-grained rocks, as indicated by relict rock slices, slip folds, and porphyroclasts.

Granoblastic rocks

Granulite or granofels-- granoblastic rocks, irrespective of mineral composition; because granulite can connote special compositions and conditions of origin, granofels may be preferred.

Quartzite, marble, and amphibolite-- compositional names that generally connote granoblastic texture; exceptions should be modified for clarity, as schistose amphibolite (or plagioclase-hornblende schist).

Tactite (skarn)-- heterogeneous calc-silicate granulites and related metasomatic rocks of typically uneven grain.

Hornfelsic rocks

All called hornfels, or, if relict features clear, hornfelsic may be used with the original rock name (as hornfelsic andesite).

Semischistose rocks

Semischist-- fine-grained (typically less than 1/4 mm) so that individual platy or lineate grains are indistinct; relict features often common.

Gneiss-- generally coarser than 1/2 mm with small aggregates of platy or lineate grains forming separate lenses, blades, or streaks in otherwise granoblastic rock. Platy or lineate structures may be distributed evenly through the rock or may be concentrated locally so that some layers or lenses are granoblastic or schistose (banded gneiss).

Cataclastic rocks

Where original nature of rock is still apparent, rock name can be modified by suitable adjectives (as cataclastic granite, flaser gabbro, phacoidal rhyolite).

Mylonite-- crushing so thorough that rock is largely aphanitic and commonly dark-colored; may be layered and crudely fissile but not schistose like phyllonite; porphyroclasts commonly rounded or lenticular.

Ultramylonite, pseudotachylite-- Aphanitic to nearly vitreous-appearing dark rock typically injected as dikes into adjoining rocks.

Relict and special textures and structures

If textures of low-grade metamorphic rocks are dominantly relict, original rock names may be modified (as massive metabasalt, semischistose meta-andesite). If hydrothermal alteration has produced prominent new minerals, names such as chloritized diorite and sericitized granite can be used.

Strongly metasomatized rocks with coarse or unusual textures may require such special names as greissen, quartz-schorl rock, and corundum-mica rock.

Migmatite-- mixtures of metamorphic and igneous-appearing rocks, especially of granitic veins and pods in a metamorphic rock host. Because of variety of types and variable usage of the term migmatite, these rocks might better be given such descriptive names as veined biotite schist, feldspathized quartzite, and injected gneiss.

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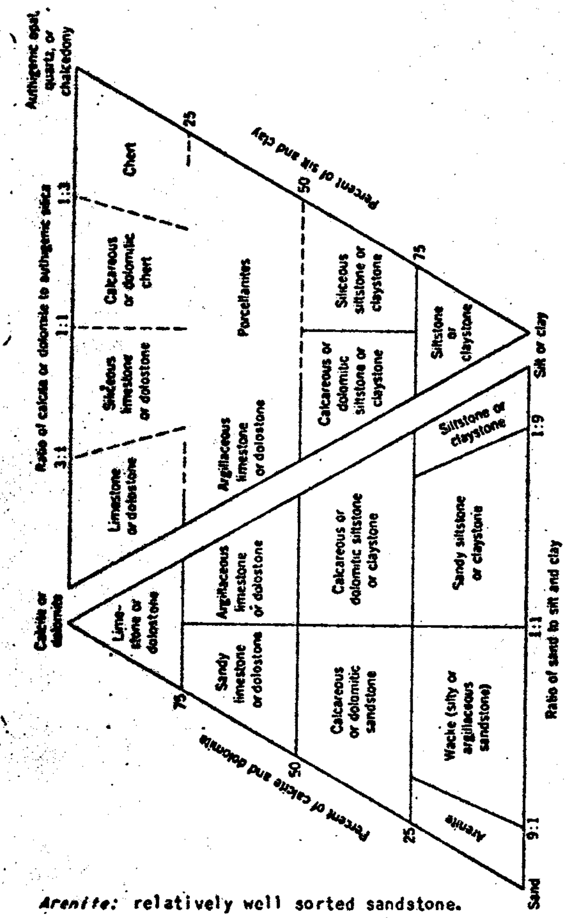
[1] Condensed from Manual of Field Geology, John Wiley and Sons, New York, (In Press).

Additional copies of this data sheet may be obtained from the AMERICAN GEOLOGICAL INSTITUTE, Cost $0.10.

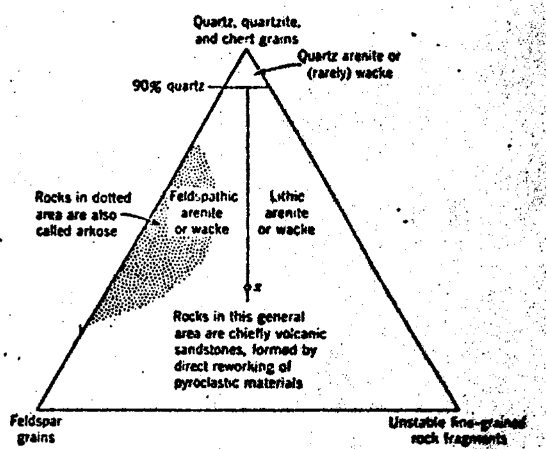
NAMES FOR SEDIMENTARY ROCKS

Condensed by R. R. Compton from *Manual of Field Geology*, John Wiley and Sons, New York, 1956

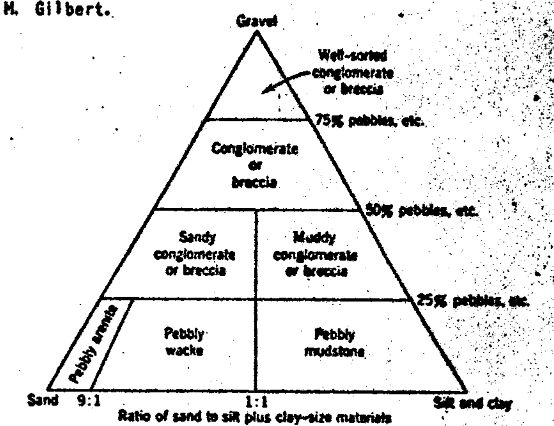


Rock Names for Mixtures of Sedimentary Materials. The sand, silt, and clay do not include detrital grains of calcite or dolomite. Mainly after C. M. Gilbert (*in* Williams, Howel, F. J. Turner, and C. M. Gilbert, 1954, *Petrography:* San Francisco, W. H. Freeman and Co., p. 270.)

Arenite: relatively well sorted sandstone.
Wacke: sandstone so poorly sorted as to include more than 10 percent of silt or clay.
Graywacke: strongly indurated dark-colored wacke.
Shale: siltstone (silty shale) or claystone (clay shale) with prominent bedding cleavage (fissility).
Mudstone: mixture of silt and clay with blocky or spheroidal fracture.
Argillite: highly indurated (generally recrystallized) claystones or siltstones that break into hard, angular fragments.



Names for Sandstones, Based on Composition. To name a rock: (1) determine the amounts of the various mineral and rock grains, (2) sum these amounts into the three groups shown at the corners of the triangle, and (3) using the proportions between the groups, estimate a point in the triangle. A poorly sorted sandstone with equal amounts of quartz, feldspar, and slate grains, for example, would fall at point *x* (a lithic, feldspathic wacke). Other detrital minerals that form more than 10 percent of the sand may be used as adjectives in the name, as *biotitic*. From a diagram supplied by C. M. Gilbert.



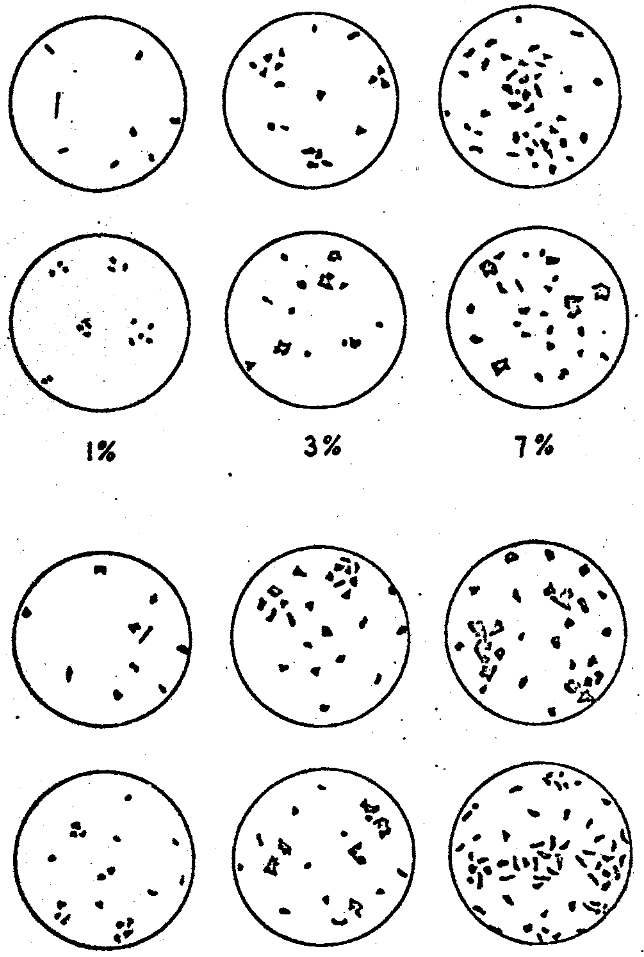
Names for Sedimentary Rocks Containing Gravel-Size Fragments

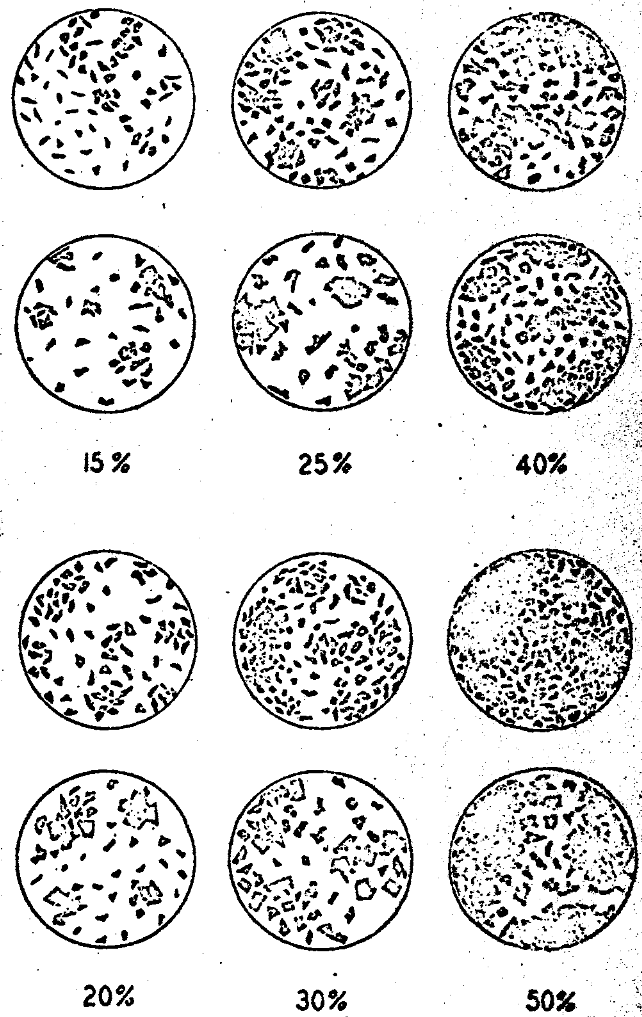
Additional copies of this data sheet may be obtained from the AMERICAN GEOLOGICAL INSTITUTE, Cost $0.10.

COMPARISON CHARTS FOR VISUAL ESTIMATION OF PERCENTAGE COMPOSITION

AGI 6

Prepared by Richard D. Terry and George V. Chilingar, Allen Hancock Foundation, Los Angeles, Calif. Reprinted from Jour. Sed. Petrol. vol. 25, no. 3, pp. 229-234, Sept. 1955.





Additional copies of this data sheet may be obtained from the AMERICAN GEOLOGICAL INSTITUTE, 2101 Constitution Ave., N.W., Washington 25, D. C. $0.10.

Geologic Column and Scale of Time

AGI 5

The tables of this data sheet were prepared by Chester R. Longwell in cooperation with the Data Sheet Committee of the American Geological Institute. The radiogenic dates were selected and checked by A. Knopf.

Kulp

ERA	SYSTEM and PERIOD	SERIES and EPOCH	STAGE and AGE: North America	STAGE and AGE: Europe	ABSOLUTE AGE
Cenozoic	Quaternary	Recent			(Duration in years)[1] Approximately the last 10,000 years.
		Pleistocene	In glaciated regions (Glacial stages underlined)		
			Wisconsin[4]	Würm[5]	10,000 ± to > 35,000 years ago
			Sangamon	Wurm-Riss	
			Illinoisan	Riss	
			Yarmouth	Riss-Mindel	
			Kansan	Mindel	
			Aftonian	Mindel-Günz	
		1	Nebraskan	Günz	
	Tertiary	Pliocene	(Atlantic and Gulf Coast)[6]	(Europe)	(millions of years ago)
			Upper	Astian	
		13	Lower	Plaisancian	
		Miocene	Upper	Sahelian: Pontian	
				Sahelian: Sarmatian	21[2]
			Middle	Tortonian	
				Helvetian	
			Lower	Burdigalian	
		25		Aquitanian	
		Oligocene	Upper	Chattian	
			Middle	Rupelian	
		36	Lower	Tongrian	
		Eocene	Jackson	Ludian	39[2]
				Bartonian	
			Claiborne	Auversian	
				Lutetian	
			Wilcox	Cuisian	
		58		Ypresian	
		Paleocene	Midway	Thanetian	
		63		Montian	60[3]
Mesozoic	Cretaceous	Upper (Late)	No accepted classification for North America generally.	Maestrichtian	70[3] 70[2]
				Campanian	
				Santonian	
				Coniacian	
				Turonian	
		90		Cenomanian	90[2]
		Lower (Early)	These European names commonly used in North America also	Albian	
				Aptian	
				Barremian	
				Hauterivian	
				Valanginian	
		135		Berriasian	
	Jurassic	Upper (Late)		Purbeckian	
				Portlandian	
				Kimeridgian	
				Oxfordian	140[3]
		Middle (Middle) — 166		Callovian	
				Bathonian	
				Bajocian	
		Lower (Early)		Toarcian	
				Pliensbachian	
				Sinemurian	
		181		Hettangian	
	Triassic	Upper (Late) 200		Rhaetian	
				Norian	
				Carnian	
		Middle (Middle)		Ladinian	
				Anisian	
		Lower (Early) 230		Scythian	

March 1958

[1]Based on hundreds of radiocarbon dates. [2]Determined by argon method; [3]By strontium method. [4]Terminology for central North America; [5]Terminology for Alps. Pleistocene marine stages also are recognized. [6]Other classifications are established for continental and Pacific Coast units.

ERA	SYSTEM and PERIOD	VARIED SUBDIVISIONS			ABSOLUTE AGE (millions of years ago)
Paleozoic	Permian	SERIES and EPOCH	STAGE and AGE		
		(West Texas)[a] Ochoa, Guadalupe, Leonard, Wolfcamp	Not established in North America	(Russia)[γ] Kazanian, Kungurian, Artinskian, Sakmarian	230[1]
	Carboniferous Systems: Pennsylvanian (?)	(Central North America) Virgil, Missouri, Des Moines, Atoka, Morrow	Not established	(Europe) Stephanian, Westphalian, Upper Namurian	
	Carboniferous Systems: Mississippian (?)	Chester, Meramec, Osage, Kinderhook	Not established	Lower Namurian, Visean, Tournaisian	
	Devonian	SERIES and EPOCH	STAGE and AGE		
		(Eastern United States)		(Europe)	
		Bradfordian	Conewango	Famennian	
		Chautauquan	Cassadaga, Chemung		
		Senecan	Finger Lakes, Taghanic	Frasnian	270[1]
		Erian	Tioughniogа, Cazenovia	Givetian, Eifelian	
		Ulsterian (?)	Onesquethaw, Deerpark, Helderberg	Coblenzian, Gedinnian	
	Silurian (425)	SERIES and EPOCH		STAGE and AGE	
		(North America) Cayugan, Niagaran, Albion	(Britain) Downtonian, Ludlovian, Wenlockian, Valentian	Not established	
	Ordovician (?)	SERIES and EPOCH	STAGE and AGE	SERIES and EPOCH	
		(North America) Cincinnatian	Gamachian, Richmondian, Maysvillian, Edenian	(Britain) Ashgillian	[illegible]
		Champlainian	Mohawkian, Chazyan	Caradocian, Llandeilian, Skiddavian	
		Canadian	Not established	Tremadocian	
	Cambrian (?)	Upper (Late), Middle (Middle), Lower (Early)	Not established	Not established	440, 470[2]
Precambrian	(No bases for world-wide divisions)	Latest Precambrian (?) (Wichita Mountains, Oklahoma)			560
		(Minnesota Scale) Keweenawan Group			1100[2]
		Pre-Keweenawan orogeny			1700[2]
		Animikie Group			
		Algoman orogeny			2100[2]
		Knife Lake Group			
		"Laurentian" orogeny			2700[2]
		Keewatin Group			
		Oldest radiogenic date reported (Southern Rhodesia)			[illegible][1]

[1]Determined by lead-uranium method; [2]By argon method; [3]By strontium method. Numbers underlined represent dates checked by two or more methods. The radiogenic dates were selected and checked by A. Knopf. [a] These provincial divisions are being extended widely in North America. [γ] Divisions in Western Europe differ somewhat from those in Russia.

Chief sources of information on terminology in these tables are: Correlation charts and articles contributed by sections of Committee on Stratigraphy, National Research Council and published in Geol.Soc.Am.Bulletin: Cenozoic, vol. 54, p. 1713 fol.; Cretaceous, vol. 53, p. 435, fol., vol. 63, p. 1011 fol., vol. 65, p. 223 fol., vol. 55, p. 1006 fol.; Jurassic, vol. 63, p. 953 fol.; Triassic, vol. 65, p. 1451 fol.; Pennsylvanian, vol. 55, p. 657 fol.; Mississippian, vol. 59, p. 91 fol.; Devonian, vol. 53, p. 1729 fol.; Silurian, vol. 53, p. 533 fol.; Ordovician, vol. 65, p. 247 fol. Other sources: Mesozoic and Permian, M. Gignoux's "Stratigraphic Geology," 4th Ed., 1950 (English trans. by G. G. Woodford), Chaps. 6-4; also "Treatise on Invertebrate Paleontology, Part L, Mollusca," R. C. Moore, Ed., Geol.Soc.Am., 1957, p. 124-129; Outline of Precambrian, Minnesota Scale, from F. F. Grout et al., "Precambrian Stratigraphy of Minnesota" Geol.Soc.Am.Bull., vol. 62, 1951, p. 1017 fol.

Kulp, Science Vol 133, #3457, p. 1111 (1961)

AGI
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CHECK LIST FOR A MINE REPORT

by John E. Allen
Portland State College

PROPERTY
- Name of property and principle ore
- Mining area or district
- County and state
- Old name or names

OWNERSHIP AND HISTORY
- Operator or lessee and address
- Present owner or owners and addresses
- Status of title: History of claims, how owned, stock ownership, corporate structure, etc.
- Previous owners
- Past mining methods
- Record of production

LOCATION
- Latitude and longitude
- Magnetic declination
- 1/4 section, section, township, range, base and meridian
- Natural landmarks
- Distances to shipping points, power lines
- Name and distance to nearest town
- Type of claim; map of claims (A) (Use bar scales on all maps)

GEOLOGY (with particular attention to the features which bear on the deposit)
- Map of areal geology and structure (B) (Sometimes combined with development map)

General
- Hand lens description of rock outcrops and wall rocks
- Percentage of outcrops versus overburden
- Topographic relations
- Geologic age and stratigraphic position of rocks
- Rock specimens (C)
- Stratigraphic, long, and cross sections (D)

Structures (note kind, attitude, spacing, and relationship to ore)
- Formational or intrusive contacts, unconformities, relationships
- Bedrock structures (bedding, jointing, and cleavage, etc.)
- Faults and fault systems

Lodes
- Attitude, shape and size of vein, lode, blanket, bed, altered zone, etc.
- Kind, size, and amount of minerals in wall rock, gangues, and ore
- Localization of ore and possible causes
- Classification (i.e., primary, secondary, replaced; relationships)
- Assay values; assay map (E), ore specimens (F)

Placer, quarry, pit
- Type (gulch, flat, hillside, etc.)
- Kind of deposit
- Shape
- Areal extent
- Depth to bedrock
- Thickness of overburden
- Composition & size range of gravels
- Presence of clay, boulders, etc.
- Value per yard
- Distribution of values
- Cultural features which might affect operation on property (waste disposal, fish damage, government restrictions, etc.)

DEVELOPMENT WORK (complete description, including as much as possible of the following)
- Sketch map or maps of development (G)
- Number, name if any, dimensions and elevations of all surface cuts, pits, trenches, portals, shaft collars
- Same as above for all underground drifts, crosscuts, raises, winzes and shafts
- Areas of ground mined out and those indicated as possible or blocked-out ore
- Location and direction of drill holes

MINING AND BENEFICIATION
- Description of mining and milling practice
  - Method of mining, moving and treating ore
  - Costs known and/or estimated of treatment
  - List of mining equipment
- Description of plant
  - List of equipment
  - Condition of buildings
  - Kind and amount of power available
  - Flow sheet (H)

ECONOMICS (these notes often "confidential")
- Costs of mining, milling, shipping, etc.
- Tonnage or yardage reserves (measured, indicated, and inferred)
- Estimated life of operation
- Drawbacks to property
- Reasons for present or possible success or failure
- Owner's plans for the future
- Recommendations

GENERAL INFORMATION
- Geography, topography, relief, elevation, climate, rainfall, snowfall, length of open season
- Water: supply, rights, disposal problems
- Labor: supply, unionization, taxes
- Literature references, bibliography
  - List of previous reports, maps, shipping records, assay records, etc.
- Names and address of informants
- Photographs of property (I)

NAME of examiner:

DATE of examination:

WORK DONE AND TIME SPENT in examination:

Additional copies of this data sheet may be obtained from the AMERICAN GEOLOGICAL INSTITUTE. Cost $0.10.

GENERAL DESCRIPTION

abun, abnt	abundant
acic	acicular
alt ('ed)('ion)	altered, alteration
amt	amount
A	angular
aniso	anisotropic
amly, amlous	anomaly, anomalous
aph ('ic)	aphanitic
argl	argillaceous
av	average
bnd	band
bed	bedding, bedded
BR	bedrock
bx ('ed)	brecciated
br	broken
calc, cal	calcareous
cem	cement (ed)
clr	clear
crs	coarse
cg	coarse-grained
col	colloid
com	common
ct, cnt	contact
ctm	contamination
xl, xline	crystal, crystalline
dec	decrease
diss	disseminated
eff	effervescent
est	estimated
fab	fabric
flt	fault
fe	ferruginous
fib	fibrous
f	fine
fg	fine-grained
fiss	fissure(s)
fol	foliated
f/	for
fos	fossil (-iferous)
frac	fracture
frag	fragment
freq	frequent
fsh	fresh
fr/	from
fst	frosted
gsn, goss	gossan
grad	gradational
g	grain
gnr	granular

GENERAL DESCRIPTION (con't)

hd	hard
hex	hexagonal
horiz, hor	horizontal
hydml	hydrothermal
imp	impure
inc	inclusion
incr	increase
int	intercept interval
isot	isotropic
jt	joint
mtx	matrix
max	maximum
med	medium
mg	medium-grained
mlz	mineralized
mini	minimum
mnr	minor
mod	moderate
num	numerous
op	opaque
ornt	orientation
ox, ox'ed	oxide, oxidized
pat	patch(es)
phan'ic	phaneritic
phen	phenocryst
porph'ic	porphyritic
poss	possible
PM	post-mineral
pred	predominant
pref	preferred
pri	primary
pris	prismatic
ran	random
r	rare
rxl'ized	recrystallized
RB	rock bit
RoBit	rotary bit
R	rounded
sdy	sandy
sc	scarce
sct	scattered
sec	secondary
shr('ing)('ed)	shear(ing)(ed)
sil	siliceous
silf	silicified
sl	slight
sol	soluble
sp	sparse
sphrt	spherulite

AMERICAN SMELTING AND REFINING COMPANY

Southwestern Exploration Department

SUGGESTED ABBREVIATIONS

ROCK MATERIALS

ahf	actinolite hornfels
agl	agglomerate
ak	alaskite
al	alluvium
an, and	andesite
ap, anp	andesite porphyry
aph, aphn	aphanite
apl	aplite
argl, arg	argillite
ark	arkose
ba, bas	basalt
bnt	bentonite
boul	boulder
bx	breccia
c-argl	calcareous argillite
c-sh	calcareous shale
calh	caliche
ccg	caliche conglomerate
cht, chrt	chert
c	clay
cs	claystone
cob	cobble
cgl	conglomerate
da	dacite
dp	dacite porphyry
dia, diab	diabase
dhf	diopside hornfels
dol	dolmite(-ic)
dior	diorite
dol-ls	dolomitic limestone
ex	extrusive
fspr	feldspathized rock
fel	felsite
fp	felsite porphyry
fos-ls	fossiliferous limestone
gb	gabbro
gl	glass
gn	gneiss
gg	gouge
gr	granite
granod	granodiorite
gnl	granule
grav	gravel
grak	graywacke
hf	hornfels
ign	igneous
intr	intrusive
jas	jasper

ROCK MATERIALS (con't)

lamphre	lamprophyre
lat	latite
ls	limestone
mb	marble
meta	metamorphic (-ism)
meta-p	metaporphyry
meta-v	metavolcanic(s)
mz, monz	monzonite
mp, mzp, mz por	monzonite porphyry
mds	mudstone
ob	obsidian
peb	pebble
peg	pegmatite
perd	peridotite
perl	perlite
phan	phanerite
phyl	phyllite
piso	pisolite
porph, por	porphyry
pum	pumice
qtz	quartz
qfr	quartz-feldspar rock
qtzite, qtzt	quartzite
rhy	rhyolite
rk	rock
sd	sand
ss	sandstone
s-argl	sandy argillite
sch	schist
sed	sedimentary
sh	shale
slt	silt
slts	siltstone
sla	slate
sgrak	subgraywacke
S	sulfur
syn	syenite
tt, tac	tactite
trach	trachyte
tf	tuff
ultbc	ultrabasic(s)
vitf	vitrophyre
vol, volc	volcanic

MINERALS

act	actinolite
alk	alkali

GENERAL DESCRIPTION (con't)

spher	spherical
stn	stained
stri	striated
st	strong
sA, sAng	subangular
sR, sRoun	subrounded
tab	tabular
tr	trace
trans	transitional
tlt	translucent
tpt	transparent
vn	vein
vlt	veinlet
vert	vertical
v	very
vit	vitreous
wk	weak
wea	weathered
w/	with
zn	zone

CRYSTALS

hex	hexagonal
isom	isometric
mon	monoclinic
ortho	orthorhombic
rhom	rhombohedral
tet	tetragonal
tri	triclinic

COLOR

blk	black
brn	brown
gry	gray
grn	green
org	orange
pnk	pink
pur	purple
red	red
wht	white
yel	yellow
dk	dark
lt	light