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GEOLOGICAL FIELD BOOK

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1-20

CONTENTS

PAGE	REFERENCE	DATE

Reference Page Index

Location _____ Date _____

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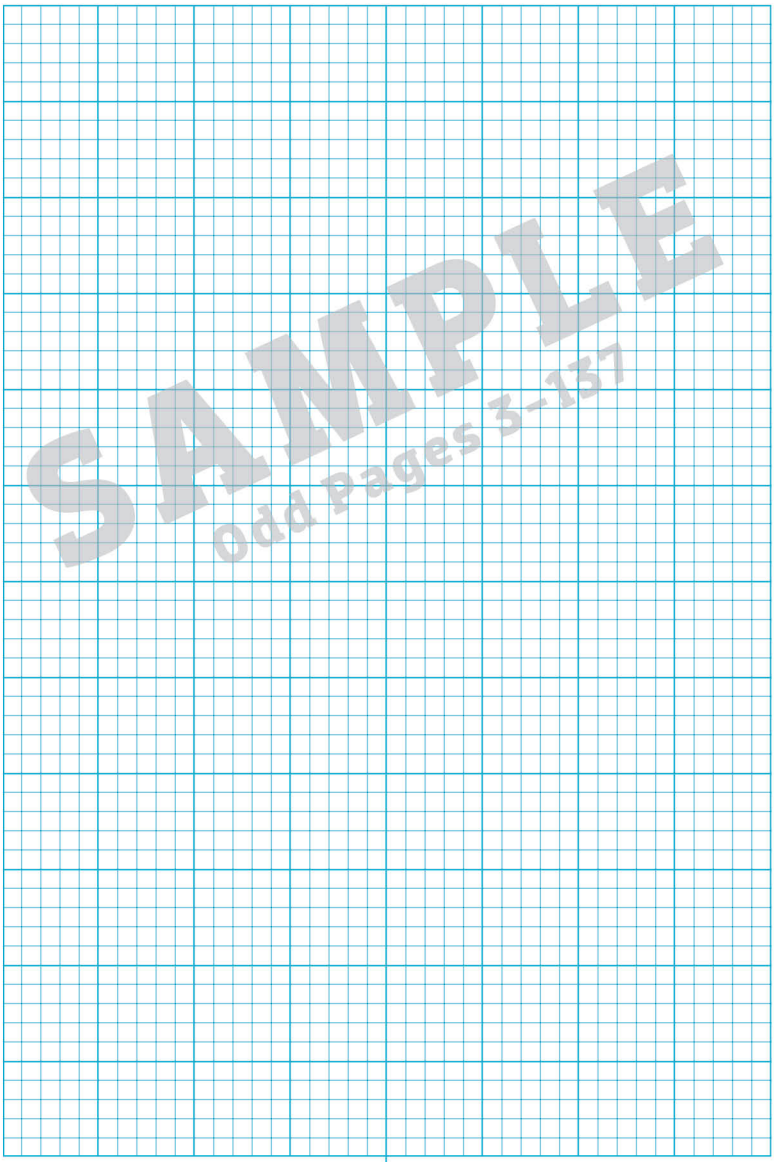

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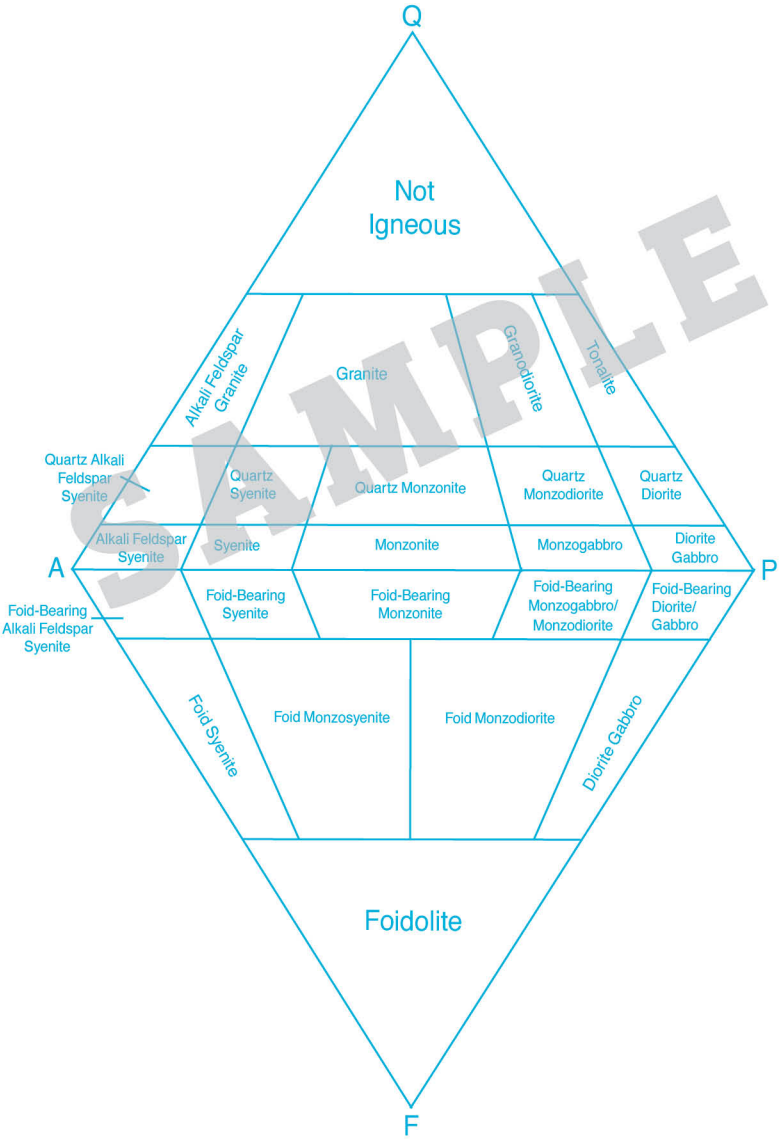
Abbreviation of Geologic Terms

abundant	abnt
acicular	acic
actinolite	Act
aggregate	Aggr
albite	Ab
amorphous	amor
amount	Amt
amphibole	Amph
amphibolite	Ampht
andalusite	Andal
angle	∠
angular	ang
andesite	And
anhedral	anhed
anhydrite	Anhy
approximate	approx
arenaceous	aren
argillaceous	arg
argillite	Arg
arkosic	ark
arsenopyrite	Ars
asphaltic	asph
average	Ave
bedded	bdd
bedding	Bdng
bentonite	Bent
biotite	Bio
bituminous	bit
boulder	Bldr
brachiopod	Brach
breccia	Bx
calcareous	calc
carbonaceous	carb
cavernous	cav
cement	Cmt
chalcedony	Chal
chalcopyrite	Cp
chlorite	Chl
claystone	Cist
cleavage	Clv
clinopyroxene	Cpx
cobble	Cbl
conglomerate	Cgl
contact	Ctc
cordierite	Cord
corundum	Cor
cross-bedding	xbdd
cross-bedding	Xbdg
cross-laminated	xlam
cross section	X sect
crystal	Xl
crystalline	xln
diameter	Diam
different	diff
diopside	Diop
disseminated	dissem
dolomite	Dol
dolomitic	dol
elevation	Elev
equivalent	equiv
evaporite	Evap
exposure	Exp
feldspatic	feld
foliated	fol
foliation	Fol
foraminifer	Foram
formation	Fm
fragmental	frag
glauconite	Glauct
granite	Gr
granodiorite	Grd
granular	gran
graptolite	Grap
graywacke	Gwke

Abbreviation of Geologic Terms

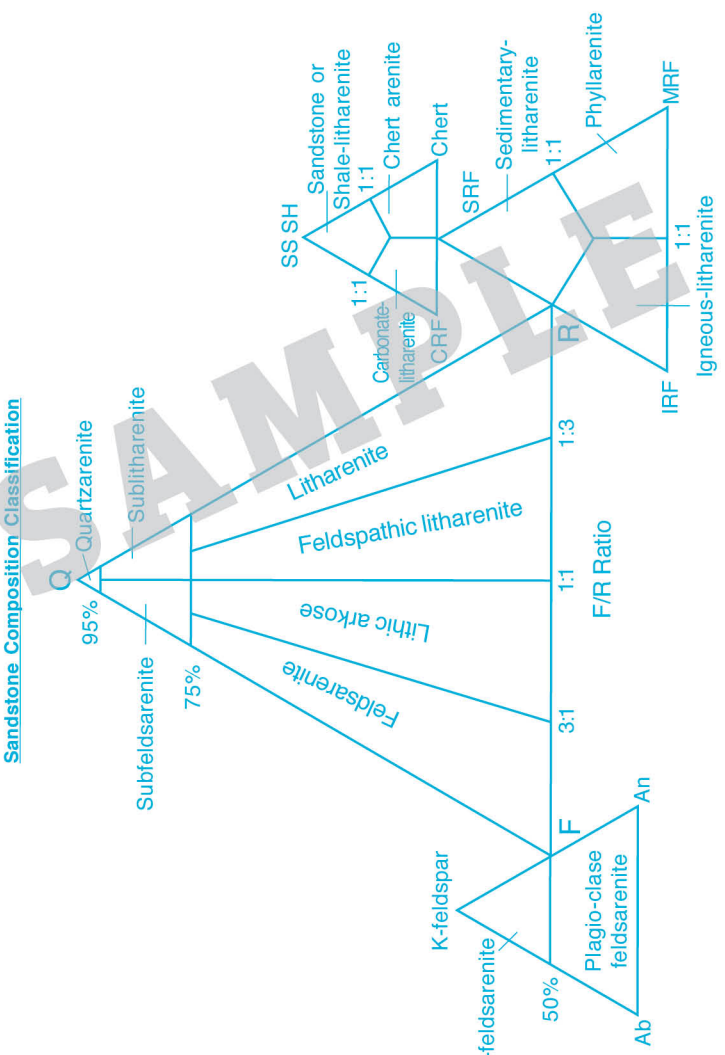
greenstone	Grnst
gypsiferous	gyp
hematitic	hem
horizontal	horiz
hornblende	Hbl
hornfels	Hfls
hypidiomorphic	hypid
igneous	ign
ignimbrite	Ignm
ilmenite	Ilm
inclusion	Incl
interbedded	intbdd
intrusion	Intr
irregular	ireg
joint	Jnt
kaolinite	Kaol
K-feldspar	Kspar
laminated	lam
limestone	Ls
limonite	Lim
lithologic	lith
magnetite	Mag
maximum	Max
member	Mbr
metamorphic	met
microline	Micr
montmorillonite	Mont
mudsstone	Mdst
muscovite	Musc
nepheline	Neph
nodular	nod
olivine	Ol
orthopyroxene	Opx
orthoclase	Orth
outcrop	Otcp
pebble	Pbl
pegmatite	Peg
peridotite	Perid
permeability	Perm
phenocryst	Pheno
phlogopite	Phlog
phosphatic	phos
plagioclase	Plag
point	Pt
porphyritic	porph
probable	prob
pyritic	py
pyroxene	Px
pyroxenite	Pxt
pyrrhotite	Pyrr
quartz	Qz
quartzite	Qzt
radiolarian	Rad
reconnaissance	Recon
regular	reg
rhyolite	Rhy
rocks	Rx
rounded	rndd
sandstone	Ss
saturated	sat
secondary	sec
sediment	Sed
sedimentary	sed
serpentine	Spt
siliceous	sil
siltstone	Sltst
soluble	sol
sphalerite	Sphal
station	Sta
staurolite	Staur
structure	Struc
stratigraphic	strat
surficial	surf
tabular	tab
temperature	T
topographic	topo
tourmaline	Tourm
tremolite	Tem
unconformity	Uncf
variegated	vrtg
vegetation	Veg
vertebrate	Vrtb
volcanic	volc
volume	Vol
wollastonite	Woll
xenolith	Xen

Classification and Characteristics of Igneous Rocks



IUGS classification of plutonic and of volcanic rocks in the double triangle Q-A-P-F, according to their actual mineral content. *(After Streckeisen, 1973, 1976, 1979).*

Sandstone Composition Classification



Folk, R.L, Andres, and D.W. Lewis, 1970. Detrital sedimentary rock classification and nomenclature for use in New Zealand: New Zealand Journal of Geology and Gephysics, v.13, Fig 8, p.955 , and Fig 9, p.959, British Crown copyright.

MEASUREMENT CONVERSIONS

U.S. to METRIC	METRIC to U.S.
inches x 2.54 = centimeters	centimeters x 0.394 = inches
feet x 0.3048 = meters	meters x 3.28 = feet
yards x 0.914 = meters	meters x 1.094 = yards
miles x 1.609 = kilometers	kilometers x 0.621 = miles
quarts x 0.946 = liters	liters x 1.057 = quarts
gallons x 3.785 = liters	liters x 0.264 = gallons
ounces x 28.349 = grams	grams x 0.035 = ounces
lbs x 0.454 = kilograms	kg x 2.205 = lbs
mpg x 0.425 = km/ltr	km/ltr x 2.352 = mpg
mph x 1.609 = km/hr	km/hr x 0.621 = mph
°F to °C (F - 32) x .555	°C to °F (C x 1.8) + 32

ENGLISH LINEAR MEASUREMENTS

12 inches = 1 foot
36 inches = 1 yard
3 feet = 1 yard
1,760 yards = 1 mile statute
2,025.37 yards = 1 mile nautical
5,280 feet = 1 mile statute
6,076.12 feet = 1 mile nautical
63,360 inches = 1 mile statute
72,913.4 inches = 1 mile nautical

MAP SCALES—ENGLISH & METRIC

SCALE	1 INCH =	1 CENTIMETER =
1:10,000	833.33 feet 254 meters	328.1 feet 100 meters
1:25,000	2,083.3 feet 635 meters	820.2 feet 250 meters
1:50,000	4,166.7 feet 1,270 meters	1,640.4 feet 500 meters
1:63,360	5,280 feet 1,609.3 meters	2,078 feet 633.6 meters
1:100,000	8,333.3 feet 2,540 meters	3,280.8 feet 1,000 meters
1:250,000	20,833 feet 6,350 meters	8,202 feet 2,500 meters
1:500,000	41,667 feet 12,700 meters	16,404 feet 5,000 meters

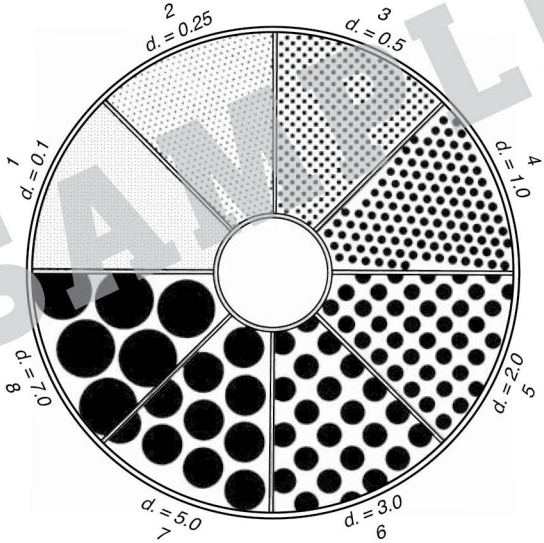
Grain-size Scales

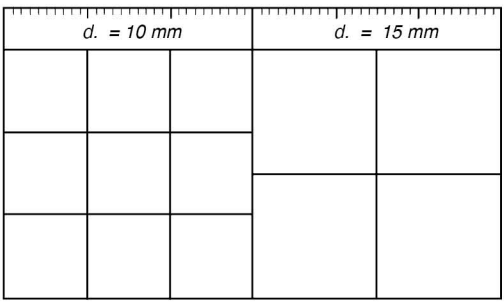
By Roy L. Ingram, University of North Carolina. Modified Wentworth scale.
V28, p.936-938. copyrighted by The American Geophysical Union.

mm	inches	phi	mm	GRADE NAME	U.S. Standard Sieve Series
4096	161.3	-12		very large	
2048	80.6	-11		large	
1024	40.3	-10		Boulders	
512	20.2	-9		medium	
256	10.1	-8		small	
128	5.0	-7		large	
64	2.52	-6		Cobbles small GRAVEL	63 mm
32	1.26	-5		very coarse	31.5 mm
16	0.63	-4		coarse	16 mm
8	0.32	-3		medium Pebbles	8 mm
4	0.16	-2		fine	No. 5
- 2 -	0.08	- 1 -		very fine	No. 10 -
1	0.04	0		very coarse	No. 18
1/2		+1	0.500	coarse	No. 35
1/4		+2	0.250	medium Sand SAND	No. 60
1/8		+3	0.125	fine	No. 120
-1/6-		-+4-	0.062-	very fine	No. 230-
1/32		+5	0.031	coarse	
1/64		+6	0.016	medium Silt	
1/128		+7	0.008	fine	
1/256		+8	0.004	very fine MUD	
1/512		+9	0.002	coarse	
1/1024		+10	0.001	medium Clay size	
1/2048		+11	0.0005	fine	
1/4096 -		-+12 -	0.00025-	very fine	

Graph for Determining the Size of Sedimentary Particles
G. V. Chilingar - AAPG Bulletin

DARK PARTICLES

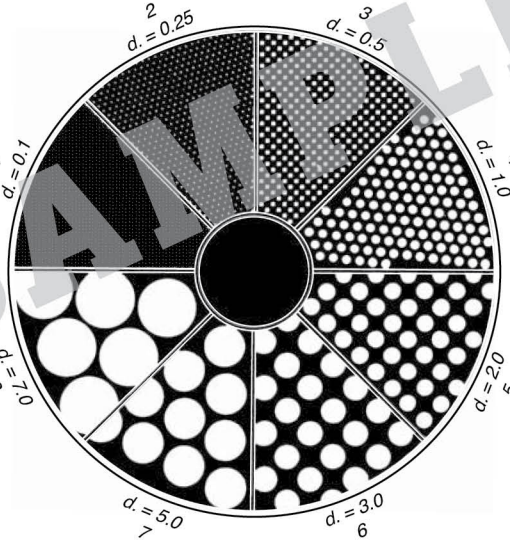


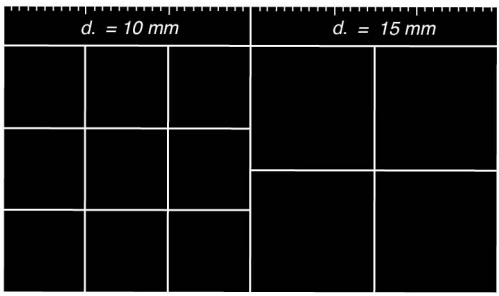


Place sand grains or rock particles in the central part of the circle. Compare the size of the particles with those on the graph with the aid of a magnifying glass. Record the corresponding number (1, 2, 3, 4, 5, 6, 7, 8) in notebook. For samples with particles of varying sizes, record the most common size first.

Graph for Determining the Size of Sedimentary Particles
G. V. Chilingar - AAPG Bulletin

LIGHT PARTICLES

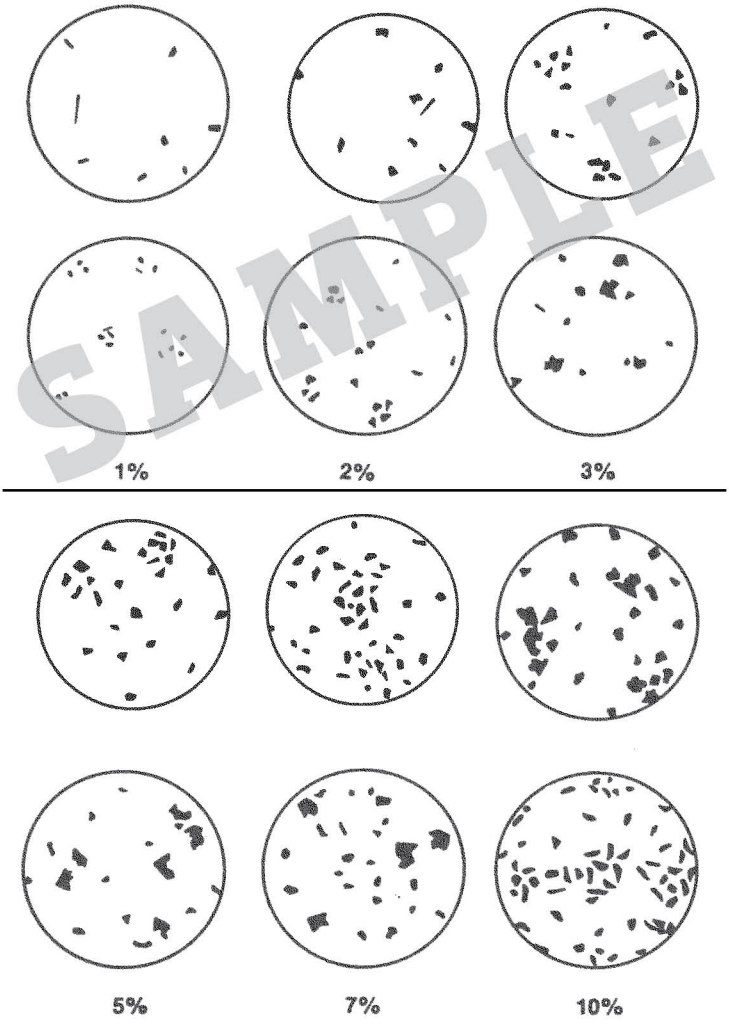




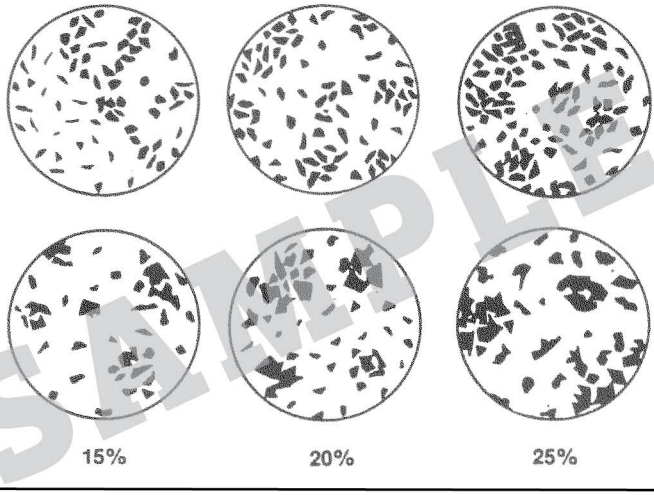
References: G. V. Chilingar, - AAPG Bulletin, Vol. 40, No. 7, AAPG© 1956, reprinted by permission of the American Association of Petroleum Geologists whose permission is required for future use.

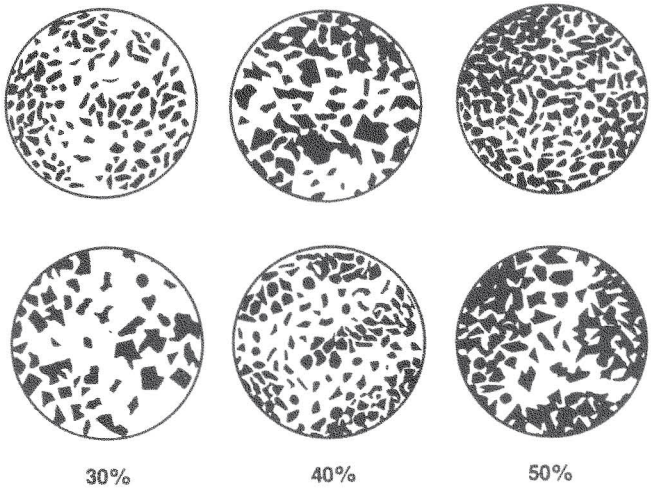
Comparision Chart for Estimating Percentage Composition

Reprinted from *Journal of Sedimentary Petography,* V . 25, N. 2, p. 229-234. Sept. 1955



Comparision Chart for Estimating Percentage Composition





Soil Classification

Coarse-grained Soils More than half of material is larger than No. 200 sieve	Gravel More than half of coarse fraction is larger than No. 4 sieve size	Clean gravels (Little or no fines)	GW	Well-graded gravels, gravel sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel sand mixtures, little or no fines.
		Gravels with fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	Sands More than half of coarse fraction is smaller than No. 4 sieve size	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly- graded sands, gravelly sands, little or no fines.
		Sands with fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
Fine-grained Soils More than half of material is smaller than No. 200 sieve	Silts and Clays Liquid limit less than 50		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			OL	Organic silts and organic silty clays of low plasticity.
	Silts and Clays Liquid limit greater than 50		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of medium to high plasticity, organic silts.
	Highly Organic		Pt	

Soil Classification

	Millimeters	Inches	Sieve Sizes
Boulders	>300	>11.8	-
Cobbles	75 - 300	2.9 - 11.8	-
Coarse Gravel	75 - 19	2.9 - .75	-
Fine Gravel	19 - 4.8	.75 - .19	3/4" - No. 4
Coarse Sand	4.8 - 2.0	.19 - .08	No. 4 - No. 10
Medium Sand	2.0 - .43	.08 - .02	No. 10 - No. 40
Fine Sand	.43 - .08	.02 - .003	No. 40 - No. 200
Fine Silt & Clay	<.08	<.003	>No. 200

Clay

Clay Consistency	Thumb Penetration	SPT, N Blows/Ft.	Undrained shear strength c (PSF) Torvane	Unconfined Compressive Strength q Pocket Penetrometer
Very Soft	Penetrated several inches by thumb. Escapes between thumb and fingers when squeezed in hand.	<2	250	500
Soft	Penetrated one inch by thumb. Molded by light finger pressure.	2 - 4	250 - 500	500 - 1000
Medium Soft	Penetrated over 1/4" by thumb with moderate effort. Molded by strong finger pressure.	4 - 8	500 - 1000	1000 - 2000
Stiff	Indented 1/4" with thumb, but only penetrated with great effort.	8 - 15	1000 - 2000	2000 - 4000
Very Stiff	Readily indented by thumbnail.	15 - 30	2000 - 4000	4000 - 8000
Hard	Indented only with difficulty, by thumbnail.	>30	>4000	>8000

Sand

Soil Type	SPT N Blows/Ft.	Relative Density%	Field Test
Very Loose Sand	4	0 - 15	Easily Penetrated with 1/2" rod pushed by hand.
Loose Sand	4 - 10	15 - 35	Easily Penetrated with 1/2" rod pushed by hand.
Med. Dense Sand	10 - 30	35 - 65	Penetrated a foot with 1/2" rod driven with a 5 lb hammer.
Dense Sand	30 - 50	65 - 85	Penetrated a foot with 1/2" rod driven with a 5 lb hammer.
Very Dense Sand	50	85 - 100	Penetrated inches with 1/2" rod driven with a 5 lb hammer.

Metamorphic Rocks

STRUCTURE	TEXTURE	CHARACTERISTIC PROPERTIES	CHARACTERISTIC MINERALOGY	ROCK NAME
FOLIATE	FINE GRAINED	1. Dull luster 2. Very flat fracture* surface 3. Grains too small to identify 4. More dense than shale	Minerals identified only wth microscope or X-rays	SLATE
		1. Silky sheen 2. Crenulated* (Wavy) fracture structure 3. A few grains may be seen, but generally microscopic in size	Development of visible mica or hornblende may have begun	PHYLLITE
	COARSE-GRAINED	1. Sub-parallel orientation of individual mineral grains 2. Commonly resembles "packed, wet leaves," i.e., wavy sheet-like fracture 3. Rock often contains porphyro-blasts 4. Thinly foliated	Mica - abundant Quartz - common Feldspar -inconspicous Hornblende	SCHIST
		1. Sub-parallel, alternating bands or layers of light and dark minerals 2. Coarsely foliated 3. Blocky fracture	Feldspar - abundant Quartz - common Mica - common Hornblende - common	GNEISS
NONFOLIATE	MASSIVE GRANULAR	1. Interlocking crystals 2. Effervesces in dilute HCl 3. Rock is softer than glass	Calcite	MARBLE
		1. Nearly equigranular grains 2. Fractures across the grains - not around them 3. Sub-vitreous appearance 4. Smooth feel when compared with sandstone	Quartz	QUARTZITE

General Increase in degree of metamophism and grain size

Metamorphic Rocks

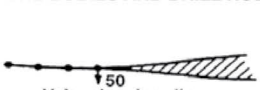
*Flat fracture =

*Crenulated fracture =

Geological Map Symbols

Surface Openings

ORE BODIES AND DRILL HOLES



Vein, showing dip


High-grade ore


Altered wall rock, showing intensity of alteration


Stringers or veinlets of mineralization


Low-grade mineralization


Vertical drill hole


Vein of high-grade mineralized rock


Vein of low-grade mineralized rock

Inclined drill hole, showing bearing, inclination, and position of bottom of hole

LARGE-SCALE MAPS


Vertical shaft


Inclined shaft


Portal of tunnel or adit


Portal and open cut


Trench


Small prospect pit or open cut


Large open pit, quarry, or glory hole


Dump

SMALL-SCALE MAPS


Vertical shaft


Inclined shaft

Portal of tunnel or adit


Trench


Prospect pit


Mine, quary, glory hole, or large open pit


Sand, gravel, or clay pit

Geologic Map Symbols

FOLIATION AND CLEAVAGE*

Strike and dip of foliation

Strike and dip of cleavage


Strike of vertical foliation


Strike of vertical cleavage


Horizontal foliation


Horizontal cleavage


Alternative symbols for other planar elements

JOINTS

Strike and dip of joint

Strike of vertical joint


Horizontal joint

Strikes and dips of multiple systems

BEDDING

Strike and dip of beds


Horizontal beds


Approximate strike and dip

Strike of vertical beds

Strike and dip of beds where top of beds 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

*The map explanation should always specify the kind of cleavage mapped

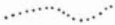
Geologic Map Symbols

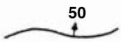
CONTACTS


Contact

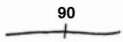

Approximate contact


Inferred contact


Concealed contact



Contact, showing dip



Vertical contact

LINEATIONS

Bearing and plunge of lineations

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

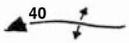

Vertical foliation, showing horizontal lineation

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 exes

FOLDS



Anticline, showing crestline and plunge

Overturned anticline, showing trace of axial suface, dip of limbs and plunge

Minor anticline, showing plunge

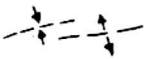
Syncline, showing crestline and plunge


Overturned syncline, showing trace of axial surface and dip of limbs

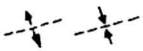
Minor syncline, showing plunge

Geologic Map Symbols

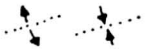
FOLDS (continued)



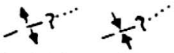
Approximate axes



Inferred axes



Concealed axes



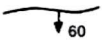
Doubtful axes, doted where concealed

Horizontal fold axes

Dome

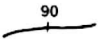
Fold with inclined axial plane, showing dip and bearing of plane and plunge of axis

FAULTS



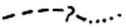
Fault, showing dip

Approximate fault



Vertical fault

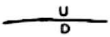
Inferred fault



Doubtful fault, dotted where concealed

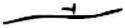
Concealed fault

Normal fault, hachures on down side



High angle fault, movement - U)up) and D (down)

Fault, showing relative movemwnt



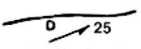
Thrust or low-angle reverse faults; T, upper plate

Thrust or reverse fault, barbs on side of upper plate

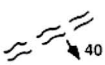
Normal fault, showing bearing and plnge of relative movement of downthrown block (D)

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

Lineament



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

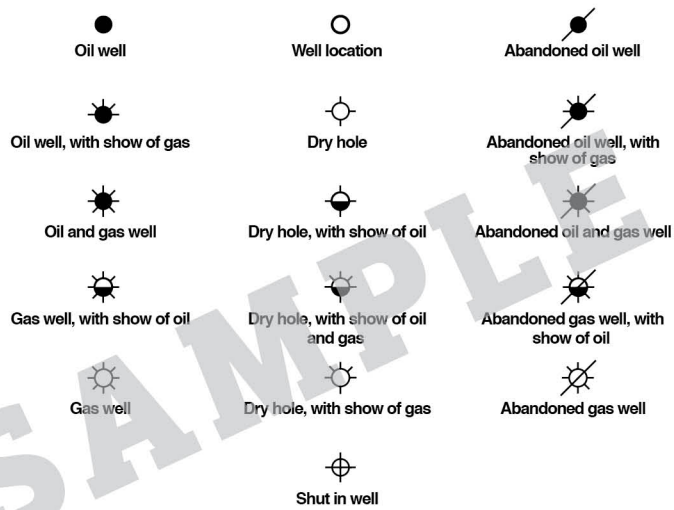


Fault zone or shear zone, showing dip

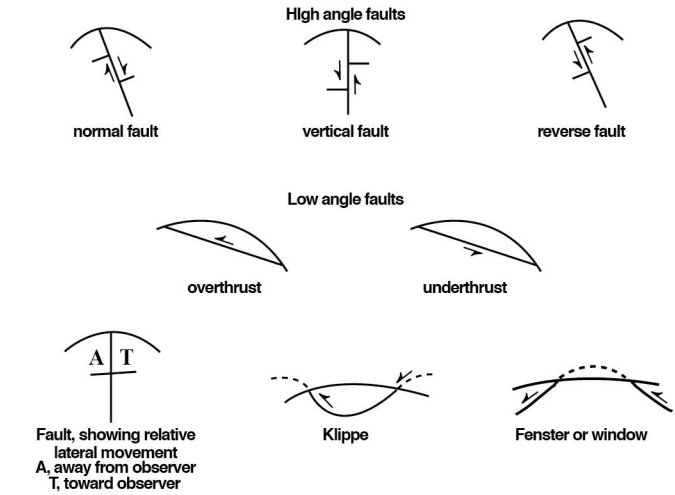
Fault breccia

Geologic Map Symbols

OIL AND GAS WELLS



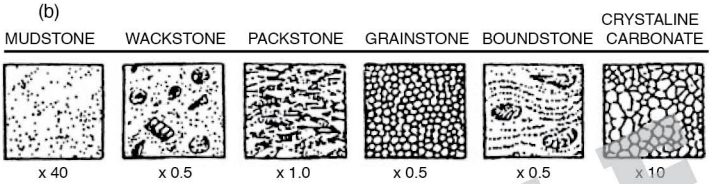
CROSS SECTIONS



(a) **Depositional texture recognizable** — **Not recognizable**

Contains mud (Mud-supporterd, <10% grains) | Lacks mud and is grain supported (Grain-supported, >10% grains) | Original components bound together

(b)



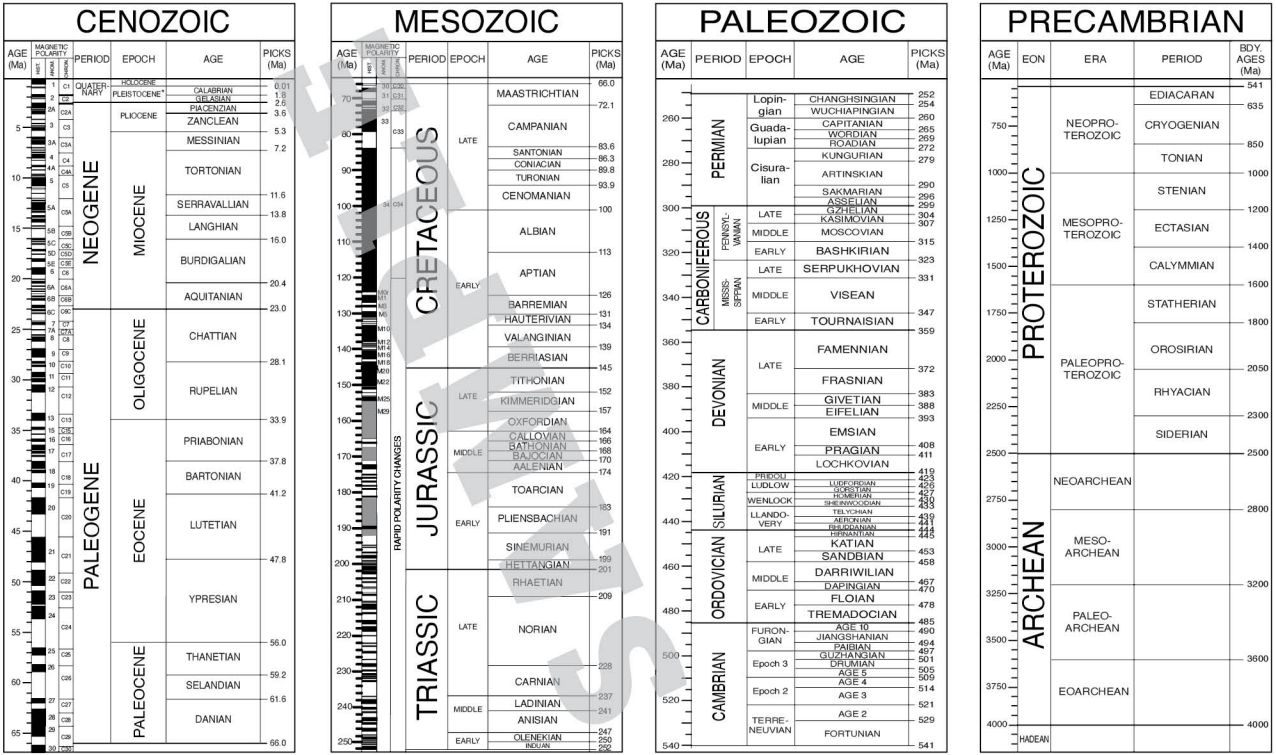
Predominantly calcite (Cc > 95%)	Dominantly calcite (95%>Cc>50%) with dolomite	Dominantly dolomite (Do >50%)	Thoroughly recrystallized rocks with some relict stuctures	
			Dominantly dolomite	Dominantly calcite
Lime Mudstone	Dolomitic lime mudstone	Dolomudstone	Crystalline dolostone	Crystalline limestone
Wackestone	Dolomitic wackestone	Dolowackestone		
Packstone	Dolomitic packstone	Dolopackstone		
Grainstone	Dolomitic grainstone	Dolograinstone		
Boundstone	Dolomitic boundstone	Dolobounstone		

Increasing gravel content →

% Gravel (>2mm) in whole rock, as determined in outcrop

Mud <0.06mm	Trace (<0.01%)	<1	1-5	5-80	80-95	95-100
Increasing mud content / Sand to mud ratio of matrix ↑	Mudstone (M)	Mudstone with dispersed clasts (Mc)	Clast-poor muddy diamicite (M[D])	Clast-rich muddy diamicite (MD)	Muddy conglomerate (MC)	Conglomerate (C)
	Sandy mudstone (SM)	Sandy mudstone with dispersed clasts (SMc)	0.54		Conglomerate (C)	
			Clast-poor intermediate diamicite (I[D])	Clast-rich intermediate diamicite (D)		
	Muddy sandstone (MS)	Muddy sandstone with dispersed clasts (MSc)	1.86			
			Clast-poor sandy diamicite (S[D])	Clast-rich sandy diamicite (SD)		
	Sandstone (S)	Sandstone with dispersed clast (Sc)	Gravelly sandstone (SG)		Sandy conglomerate (SC)	

GSA GEOLOGIC TIME SCALE v. 4.0



Walker, J.D., Geissman, J.W., Bowring, S.A., and Babcock, L.E., compilers, 2012, Geologic Time Scale v. 4.0: Geological Society of America, doi: 10.1130/2012.CTS004R3BW. ©2012 The Geological Society of America.

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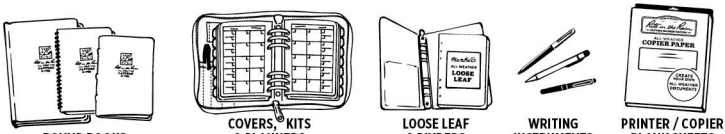

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