DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-631
SHEET 3 OF 3

TABLE 2.--GEOLOGIC CHARACTERISTICS OF SURFICIAL UNITS

Geologic characteristics	Colluvium Qco	Post-Piney Creek alluvium Qpp (Scott, 1960)	Piney Creek Alluvium Qp (Hunt, 1954)	Eolian sand Qes	Loess Qlo	Broadway Alluvium Qb (Scott, 1960)	Louviers Alluvium Ql (Scott, 1960)	Slocum Alluvium Qs (Scott, 1960)
Dominant sediments	Stony sand, silt, and clay.	Sand, silt, and fine gravel; some clay.	Silt, sand, clay, and fine gravel.	Sand; some silt.	Silt; some fine sand.	Clayey silt, sand, and gravel.	Sand, silt, and gravel.	Sand, silt, and gravel.
Maximum observed thickness	15 ft (4.6 m) in roadcut; commonly mantles slopes to depths less than 5 ft (1.5 m).	15 ft (4.6 m) by hand auger; may be thicker in stream valleys.	15 ft (4.6 m) in excavation. May be thicker in stream valleys.	30 ft (9.1 m) by power hand auger.	22 ft (6.7 m) by power hand auger. Thickest on upper parts of southeast-facing slopes.	25 ft (7.5 m) in stream cut.	20 ft (6 m) with power hand auger.	25 ft (7.5 m) with power hand auger.
Color	Generally shades of brown and gray, dependent on source unit.	Light yellowish gray to grayish yellow.	Brown, brownish gray, and pale brown.	Reddish orange to reddish brown.	Reddish brown, yellowish brown, grayish brown.	Dark yellowish brown to medium gray.	Light reddish brown to yellowish brown.	Dark reddish brown, yellowish brown, and olive gray.
Bedding[4] (fig. 1)	Chaotic to poorly graded bedding.	Trough-shaped crossbedding; local gravel bars.	Trough-shaped crossbedding; tabular and lenticular layers; local gravel bars.	Trough-shaped and tangential crossbedding.	Tangential crossbedding, poorly developed.	Tangential and trough-shaped crossbedding; lenticular layers.	Low-angle trough-shaped and tangential crossbedding.	Trough-shaped crossbedding dominant.
Grain size (fig. 2)	Ranges from clay to boulders.	Mostly less than 1 mm.	Mostly less than 0.5 mm.	Mostly less than 0.125 mm.	Mostly less than 0.05 mm.	Mostly 0.02-4 mm.	Mostly 0.01-0.25 mm; local boulder gravel as large as 25 mm.	Mostly 0.01-0.25 mm; local boulder gravel as large as 25 mm.
Sorting[5] (fig. 2)	Unsorted to moderately sorted.	Well sorted in horizontal layers; poorly sorted vertically.	Moderately well sorted.	Well sorted.	Poorly sorted; contains some secondary fine gravel and sand.	Poorly sorted.	Unsorted.	Unsorted to moderately well sorted.
Grain shape[6]	Equant, tabular.	Equant, tabular.	Mostly equant; some tabular.	Equant.	Equant.	Equant, tabular.	Equant, tabular.	Equant.
Grain roundness[7]	Mostly subrounded to rounded.	Subrounded to subangular.	Mostly subrounded to rounded; some subangular.	Mostly subrounded; some subangular.	Mostly angular to subrounded.	Mostly rounded.	Mostly rounded; some subangular.	Mostly well rounded.
Grain surface	Variable from rough and broken to smooth.	Frosted, pitted, smooth.	Frosted, pitted, smooth.	Frosted, pitted.	Rough, pitted; some quartz grains frosted.	Mostly smooth; some rough.	Smooth to irregular.	Mostly smooth.
Composition, in order of abundance	Variable; depends on composition of source unit.	Quartz, mica, feldspar, minor rock fragments, organic debris.	Quartz, mica, organic debris, rock fragments, clay.	Quartz; some kaolinized feldspar.	Clay (kaolinite, illite, some montmorillonite, mixed-layer), quartz, feldspar.	Quartz, clay, mica, organic debris, rock fragments.	Quartz, feldspar, mica, clay, ironstone, rock fragments.	Quartz, kaolinized feldspar, mica, clay, metamorphic rock fragments.
Consistency (firmness) of engineering soils[8]	Mostly hard when dry; stiff when wet. Moderately cohesive. Locally poorly drained.	Soft when dry; moderately stiff when wet. Noncohesive. Well drained.	Very stiff when dry; soft and sticky when wet. Locally poorly drained. Moderately cohesive.	Incoherent; loose when dry; gains some cohesion when wet.	Moderately hard when dry; very soft when wet. Cohesion provided by clay.	Moderately hard when dry; very soft and sticky when wet.	Moderately firm when dry; locally soft and sticky when wet.	Stiff to hard when dry; stiff to firm when wet.
Distribution	Mantles slopes and forms lens-shaped deposits at bases of slopes.	Valley floors and beds of modern streams and some adjacent flood plains.	Forms low terraces adjacent to modern streams. Occupies valley floors, some drainageways.	Mantles low rounded slopes in western part of the quadrangle.	Mantles ridges and upland slopes in central part of the quadrangle.	Low terraces in stream valleys, 10-30 ft (3-9 m) above modern streams.	Terraces on upland surfaces, 30-80 ft (9-24 m) above principal streams in east part of quadrangle.	Pediment deposit on gently sloping upland surfaces 50-200 ft (15-60 m) above principal streams.
Development of soil zone	Uneven, irregular; depends on characteristics of source unit.	Sand and sandy clay. Soil zone locally as much as 2 ft (0.6 m) deep. Noncalcareous.	Thin sandy clay, calcareous, as deep as 6 ft (1.8 m).	Clayey sand; silty where locally mixed with loess; as deep as 4 ft (1.2 m). Noncalcareous.	Silty sandy clay. Blocky. Contains layers of fine gravel. Very calcareous. Best agricultural land.	Silty sandy clay with layers of fine gravel. Soil zone as deep as 3 ft (0.9 m). Noncalcareous.	Clayey silty sand with fine gravel layers, slightly to noncalcareous, as deep as 5 ft (1.5 m).	Silty sand; some clay; some thin beds of fine gravel. Zone as deep as 4 ft (1.2 m). Calcareous; caliche films on particles and caliche blocks at 1.5-3 ft depths (0.45-0.9 m).
General remarks	Derived by gravity, slopewash, and weathering from bedrock and surficial geologic units.	Derived by erosion and reworking of old soils, sediments, and bedrock. Very susceptible to flooding.	Includes post-Piney Creek deposits too small to map. Very susceptible to seasonal flooding.	Deposited by northwesterly winds; derived from sediments in the South Platte River valley.	Deposited by northwesterly winds; derived from sediments west of and in the South Platte River valley. Very high shrink-swell potential.	Deposited by streams, by reworking of older sediments and bedrock units. Locally subject to seasonal floods.	Deposited by meandering streams, eroded from older sediments and bedrock to the south.	Deposited by aggrading streams, overlies interbedded Dawson sandstone and claystone in this quadrangle.

TABLE 3.--COMPARISON OF GEOLOGIC UNITS ACCORDING TO SELECTED ENGINEERING CHARACTERISTICS

[Based on field observation and interpretation of physical properties tests]

Geologic units	Relative permeability		Relative frost-heave susceptibility		Relative trafficability			Relative erosion susceptibility		Relative ease of excavation in unweathered material		Relative stability of dry natural slopes		Relative stability of dry cut (manmade) slopes		Relative foundation stability[9]	
						Dry	Wet										
Bedrock units																	
Tcr Castle Rock Conglomerate	Highest	Tcr	Highest	Tdec	Best	Tcr	Tcr	Highest	Tdo	Easiest	Tdo	Most	Tda	Most	Tcr	Most	Tda
Dawson Arkose, upper part		Tdc		Tdo		Tdc	Tdc		Tds		Tdv		Tcr		Tda		Tcr
Tda Arkosic sandstone facies		Tda		Tdv		Tda	Tdes		Tdv		Tds		Tds		Tds		Tdc
Tdc Conglomerate facies		Tdes		Tdes		Tds	Tda		Tdec		Tdec		Tdes		Tdes		Tds
Tds Sandstone facies		Tds		Tds		Tdes	Tdec		Tdes		Tdc		Tdc		Tdc		Tdes
Tdo Claystone facies		Tdo		Tda		Tdo	Tds		Tda		Tda		Tdv		Tdv		Tdo
Tdv Variegated claystone facies		Tdv		Tdc		Tdv	Tdv		Tdc		Tcr		Tdo		Tdo		Tdv
Denver Formation, upper tongue	Lowest	Tdec	Lowest	Tcr	Worst	Tdec	Tdo	Lowest	Tcr	Most difficult	Tdes	Least	Tdec	Least	Tdes	Least	Tdec
Tdes Sandstone facies																	
Tdec Claystone facies																	
Surficial units																	
Qpp Post-Piney Creek alluvium	Highest	Qes-Qpp	Highest	Qp	Best	Qs	Qs	Highest	Qpp	Easiest	Qpp	Most	Qs	Most	Qs	Most	Qs
Qp Piney Creek Alluvium		Qlo (vertical)		Qlo		Ql	Ql		Qes		Qes		Ql		Ql		Ql
Qes Eolian sand		Qlo (horizontal)		Qb		Qb	Qes		Qlo		Qp		Qb		Qb		Qb
Qlo Loess		Qp		Qs		Qp	Qpp		Qp		Qb		Qlo		Qb		Qes
Qb Broadway Alluvium		Qb		Ql		Qlo	Qb		Qb		Qf		Qpp		Qpp		Qp
Ql Louviers Alluvium		Ql		Qes		Qes	Qp		Ql		Qs		Qp		Qp		Qpp
Qs Slocum Alluvium	Lowest	Qs	Lowest	Qpp	Worst	Qpp	Qlo	Lowest	Qs	Most difficult	Qlo	Least	Qes	Least	Qes	Least	Qlo

TABLE 4.--GEOTECHNICAL CHARACTERISTICS OF SELECTED SURFICIAL UNITS[10]

[All test data are results of tests on moderately weathered samples. Laboratory tests performed by George S. Erickson and Philip S. Powers, U.S. Geological Survey, 1971-73.]

Geotechnical characteristics		Loess[11] Qlo					Slocum Alluvium Qs					Louviers Alluvium Ql				
		No. of samples tested	Range	Standard[12] deviation	Mean	γ[13]	No. of samples tested	Range	Standard deviation	Mean	γ	No. of samples tested	Range	Standard deviation	Mean	γ
Particle-size distribution, in percent (hydrometer and sieve analysis--see fig. 2)	Gravel	9	0-2	0.9	1	2.3	3	0-28	15.6	18	0.9	3	0-22	12.7	7	1.8
	Very coarse and coarse sand		0-9	2.7	3	.9		0-35	18.2	20	.9		5-28	12.5	14	.9
	Medium sand		1-10	2.9	3	.9		7-46	19.5	27	.7		5-7	1	6	.2
	Fine and very fine sand		8-22	4.3	13	.3		7-33	14.4	14	1		9-18	4.9	12	.4
	Silt		31-53	7.0	43	.2		0-31	15.2	11	1.4		14-29	8.4	24	.4
	Clay		28-45	7.2	37	.2		0-29	16.7	10	1.7		20-52	16.1	37	.4
Plasticity characteristics[14], in percent (tested on part of sample passing No. 35 sieve, 0.5 mm)	Liquid limit	13	28-64	9.4	46		4	32-54	9.8	46		5	37-71	13.8	53	
	Plastic limit		21-43	5.9	28			20-28	3.6	25			21-38	6.9	29	
	Plasticity index		7-34	6.9	18			12-29	7.1	21			14-33	7.9	24	
	Plasticity index/Percent clay		-----	---	0.5			-----	---	0.7			-----	----	0.7	
Potential volume change[15] (tested on part of sample passing No. 10 sieve--2 mm)	lb/ft^2	13	600-3,200	717	1,873		4	900-4,100	1,325	2,430			400-6,900	2,680	2,960	
	kN/m^2		29-153	34	90			43-196	63	116			19-331	128	142	
	Mean rating (1-10)		0.6-3.9	---	2.3			1.1-5.2	---	3.0			0.3-8.2	-----	3.6	
	Classification		Marginal					Marginal					Marginal			
Heave[16]	Percent	1	6				Not tested					Not tested				
pH[17]		6	7.1-7.7	0.3	7.6			7.7, 7.8	---	7.75			5.5, 7.6	---	6.5	

TABLE 5.--GEOTECHNICAL CHARACTERISTICS OF SELECTED BEDROCK UNITS

[All test data are results of tests on fresh and moderately weathered samples. Laboratory tests performed by George S. Erickson and Philip S. Powers, U.S. Geological Survey, 1971-73.]

Dawson Arkose, upper part

Geotechnical characteristics		Arkosic sandstone facies Tda					Sandstone facies Tds					Claystone facies Tdo					Variegated claystone facies Tdv				
		No. of samples tested	Range	Standard[12] deviation	Mean	γ[13]	No. of samples tested	Range	Standard deviation	Mean	γ	No. of samples tested	Range	Standard deviation	Mean	γ	No. of samples tested	Range	Standard deviation	Mean	γ
Particle-size distribution, in percent (whole-rock, hydrometer, and sieve analysis--see fig. 2)	Gravel	13	0-44	15.3	16	0.96	16	0-16	0.4	1	4.0	25	0-26	5.2	1	5	5	-----	----	--	---
	Very coarse to coarse sand		12-69	16.8	36	.47		0-46	13.2	12	1.1		0-10	2.6	1	3		0-5	2.2	1	2
	Medium sand		8-27	5.8	14	.41		1-42	13	21	.6		0-25	5.5	4	1.4		0-9	3.8	4	1
	Fine to very fine sand		4-28	8.1	15	.54		16-65	12.8	35	.4		3-44	10.9	16	.7		12-38	11.4	18	.6
	Silt		2-27	9.0	10	.9		6-35	9.2	18	.5		16-50	10.3	35	.3		22-47	10.7	35	.3
	Clay		0-32	10.6	9	1.18		2-33	9.4	13	.7		4-70	14.9	43	.4		26-57	11.9	42	.3
Grain specific density (average)		3	2.64				1	2.77				1	2.66				1	2.65			
Plasticity characteristics[14], in percent (tested on part of sample passing No. 35 sieve--0.5 mm)	Liquid limit	15	0-51	17.1	32	0.53	13	21-56	9.5	39	0.2	23	37-87	11	55	0.2	4	40-65	10	48	0.2
	Plastic limit		0-36	14	15	.93		0-37	14	19	.7		25-56	9.1	37	.3		26-45	7.8	36	.2
	Plasticity index		0-23	8.4	8	1.1		0-23	9.1	8	1.1		9-31	6.7	18	.4		3-16	5.9	12	.5
	Plasticity index/Percent clay		----	----	0.8			-----	----	0.6			-----	----	0.4			-----	----	0.29	
Potential volume change[15] (tested on part of sample passing No. 10 sieve--2 mm)	lb/ft^2	14	0-4,500	1,338	940	1.4	15	0-3,100	1,075	1,470	0.7	19	1,100-6,550	1,170	3,160	0.4	6	1,400-3,500	970	2,750	0.4
	kN/m^2		0-216	64.1	45	1.4		0-148.5	51.5	70.4	.7		52.7-313.7	56	151.3	.4		67.1-167.6	46.5	131.7	.4
	Mean rating (1-10)		(0-5.7)	-------	1.2			(0-3.8)	-----	(1.4)			(1.2-8.0)	-----	(4.0)			(1.6-4.5)	----	(3.3)	
	Classification		Noncritical					Noncritical					Critical					Marginal			
Heave[16]	Percent	Not tested					1	6				10	2-13	3.7	6.3	0.6	4	2-10	3.4	6	0.6
pH[17]		12	6.5-8.0	0.6	7.4	0.1		5.9-7.9	0.75	7.0	0.1	19	4.9-7.9	0.6	7.2	0.1	4	7.1-7.9	0.4	7.3	0.1
Other tests		Unconfined compressive strength 2160-4320 tons/ft^2 1527 3240 0.5 (207-414 MN/m^2) (146) (310) .5 Compressional wave velocity 6,400 ft/sec (1,920 m/sec) Shear wave velocity 2,660 ft/sec (798 m/sec)										X-ray analysis (1 sample): Mineral / Percent of sample: Quartz 20; Clay 65; Feldspar 15 Clay fraction / Percent of total: Montmorillonite 65; Kaolinite 30; Illite 5; Chlorite Trace									

Denver Formation, upper tongue

Geotechnical characteristics		Sandstone facies Tdes					Claystone facies Tdec				
		No. of samples tested	Range	Standard deviation	Mean	γ	No. of samples tested	Range	Standard deviation	Mean	γ
Particle-size distribution, in percent (whole-rock, hydrometer, and sieve analysis--see fig. 2)	Gravel	7	-----	----	--	---	9	-----	----	--	---
	Very coarse to coarse sand		0-4	1.8	2	0.9		-----	----	--	---
	Medium sand		0-40	14.1	11	1.3		0-4	1.3	1	1.3
	Fine to very fine sand		3-50	17.3	22	.8		1-29	9.7	14	.7
	Silt		13-54	14.7	35	.4		37-65	9.8	48	.2
	Clay		10-52	16.3	30	.5		12-55	14.6	37	.4
Grain specific density (average)		1	2.70				--				
Plasticity characteristics[14], in percent (tested on part of sample passing No. 35 sieve--0.5 mm)	Liquid limit	6	43-74	12.9	61	0.2	15	51-95	10.8	68	0.2
	Plastic limit		0-45	16.2	30	.5		28-59	8.4	44	.2
	Plasticity index		14-66	18.1	31	.6		11-52	10.2	24	.4
	Plasticity index/Percent clay		-----	----	1.03			-----	----	0.65	
Potential volume change[15] (tested on part of sample passing No. 10 sieve--2 mm)	lb/ft^2	6	1,250-9,900	3,254	5,242	0.6	15	2,300-11,400	2,414	6,133	0.4
	kN/m^2		59.9-474.1	156	251	.6		110.2-546	116	294	.4
	Mean rating (1-10)		(1.4->9.0)	-----	6.5			(2.8->9)	-----	7.5	
	Classification		Very critical					Very critical			
Heave[16]	Percent	Not tested					7	10-23	4.5	14	0.3
pH[17]		4	7.5-7.7	1.2	7.6	0.2	15	6.8-7.5	0.2	7.2	0.03
Other tests		3 Unconfined compressive strength 65-486 tons/ft^2 215 299 0.72 (6-47 MN/m^2) (21) (29) .72 3 Compressional wave velocity 6,400-8,880 ft/sec 1,243 7,690 0.2 (1,920-2,664 m/sec) (373) (2,307) .2 3 Shear wave velocity 2,660-4,900 ft/sec 1,147 3,640 0.3 (798-1,470 m/sec) (344) (1,092) .3									

FOOTNOTES

Table 1

[1] Thicknesses were measured in the field in feet, and were converted arithmetically to metric measurements.
[2] Color designations are from Goddard and others (1948).
[3] See sorting entries on tables 4 and 5.

Table 2

[4] Bedding according to classification of Potter and Pettijohn (1963, p. 69). See Pettijohn (1957, fig. 25).
[5] From Pettijohn (1957, p. 33, fig. 17).
[6] From Pettijohn (1957, p. 56 and fig. 25).
[7] From Pettijohn (1957, p. 59 and fig. 28).
[8] Unconfined compressive strength, based on field tests with pocket Penetrometer (Soiltest Model CL-700) and converted to the following scale (Geological Society Engineering Group Working Party, 1972):

Consistency	kN/m^2	Tons/ft^2
Hard-------	>288	>3
Stiff------	144-288	1.5 -3
Firm-------	72-144	0.75-1.5
Soft-------	36-72	0.38-0.75
Very soft--	<36	<0.75

Table 3

[9] This is the most subjective, or judgment, evaluation of this table. Because of the nonurbanized nature of the quadrangle, most bedrock units either have not been excavated for foundations, or the foundations of buildings are not old enough to have a history of performance. This evaluation is based on field observations of relative permeability, frost-heave susceptibility, erosion susceptibility, natural-slope stability, shrink-swell potential, and natural susceptibility to compaction.

Tables 4 and 5

[10] Other surficial units not tested, except for one sample each of Piney Creek Alluvium and post-Piney Creek alluvium, tested for particle-size distribution. Results of these tests are shown on figure 2.
[11] Field observations indicate that loess has a high shrinkage potential when the material is wetted. Loess that is wetted, compacted, and allowed to dry expands slightly upon re-wetting, as shown above.
[12] Standard deviation: within the range of the mean plus and minus, one standard deviation will fall 68.3 percent of the values for the samples tested.
[13] γ: coefficient of variation, the ratio $\frac{\sigma}{\bar{x}}\left(\frac{\text{standard deviation}}{\text{mean}}\right)$.
[14] Liquid limit: percentage of water contained in a sample when the sample passes from the plastic state into the liquid state; that is, when it begins to flow. The higher the liquid limit, the more compressible the material.
Plastic limit: percentage of water contained in a sample when the sample passes from the solid state into the plastic state; that is, when it will deform without rebound or rupture.
Plasticity index: the difference between liquid limit and plastic limit. The higher the plasticity index, the more plastic the sample is in its natural undisturbed state.
Plasticity index/Percent clay: activity of clays, a derived indicator of clay behavior under load.
[15] Potential volume change is the pressure, due to expansion upon wetting, that may be exerted by the material on a restraining structure. Pressure here is expressed in pounds per square foot and in kilonewtons per square meter. One kN/m^2 = 145×10^{-3} lb/in^2. Mean rating is on a scale of 1 to 10, and indicates the necessity of using sound engineering practice in overcoming the instability of the material.

POTENTIAL VOLUME CHANGE
(From Lambe, 1960)

lb/ft^2 range	kN/m^2 range	Rating	Classification
1,700	0- 81	1	Noncritical
>1,700-<3,200	>81-<153	2 3	Marginal
3,200-<4,700	153-<225	4 5	Critical
4,700-<8,000	225-<382	6 7 8 9	Very critical
>8,000	>383	9	Hypercritical

[16] Heave: the amount of heaving, expressed as percent volume increase of a sample in a consolidometer, is measured for a low confining pressure (200 lb/ft^2; 9.6 kN/m^2) after the sample is given access to water.
[17] pH: a measure of the relative acidity of the sample. pH of 7.0 is neutral; more than 7.0 is alkaline and less than 7.0 is acidic. Alkalinity and acidity increase away from neutrality. Excessively alkaline or acidic material requires special engineering techniques to prevent harmful chemical reactions in dams, foundations, pilings, and other works of man.

Figures 5 and 6

[18] Coefficient of sorting ($So = \sqrt{Q_3/Q_1}$) is a statistical measure of the dominance of size ranges in a unit. In this study, well-sorted units have So <3.1; moderately to moderately well sorted units have So <5.6; poorly sorted units have So >5.6; the three samples of Louviers Alluvium gave So = 17.3 and are classed as unsorted.

REFERENCES

Cross, Whitman, 1888, The Denver Tertiary Formation: Colorado Sci. Soc. Proc., v. 3, pt. 1, p. 119-133.
Geological Society Engineering Group Working Party, 1972, The preparation of maps and plans in terms of engineering geology: Quart. Jour. Eng. Geology, v. 5, no. 4, p. 293-382.
Goddard, E. N., chm., and others, 1948, Rock-color chart: Natl. Research Council (repr. by Geol. Soc. America, 1951, 1970), 6 p.
Hunt, C. B., 1954, Pleistocene and Recent deposits in the Denver area, Colorado: U.S. Geol. Survey Bull. 996-C, p. 91-140.
Lambe, T. W., 1960, The character and identification of expansive soils: [U.S.] Federal Housing Adm. Tech. Studies Rept., 51 p.
Lee, W. T., 1902, The areal geology of the Castle Rock region, Colorado: Am. Geologist, v. 29, p. 96-110.
Maberry, J. O., 1971, Sedimentary features of the Blackhawk Formation (Cretaceous) in the Sunnyside district, Carbon County, Utah: U.S. Geol. Survey Prof. Paper 688, 44 p., 3 pls.
Pettijohn, F. J., 1957, Sedimentary rocks [2d ed.]: New York, Harper & Brothers, 718 p.
Potter, P. E., and Pettijohn, F. J., 1963, Paleocurrents and basin analysis. New York, Academic Press, 296 p.
Richardson, G. B., 1912, The Monument Creek Group: Geol. Soc. America Bull., v. 23, p. 267-276.
Scott, G. R., 1960, Subdivision of the Quaternary alluvium east of the Front Range near Denver, Colorado: Geol. Soc. America Bull., v. 71, no. 10, p. 1541-1543.

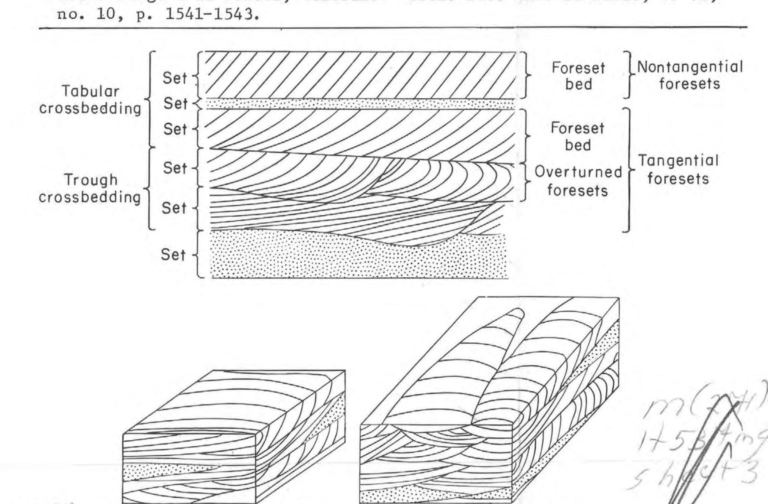

FIGURE 1.--CROSSBEDDING

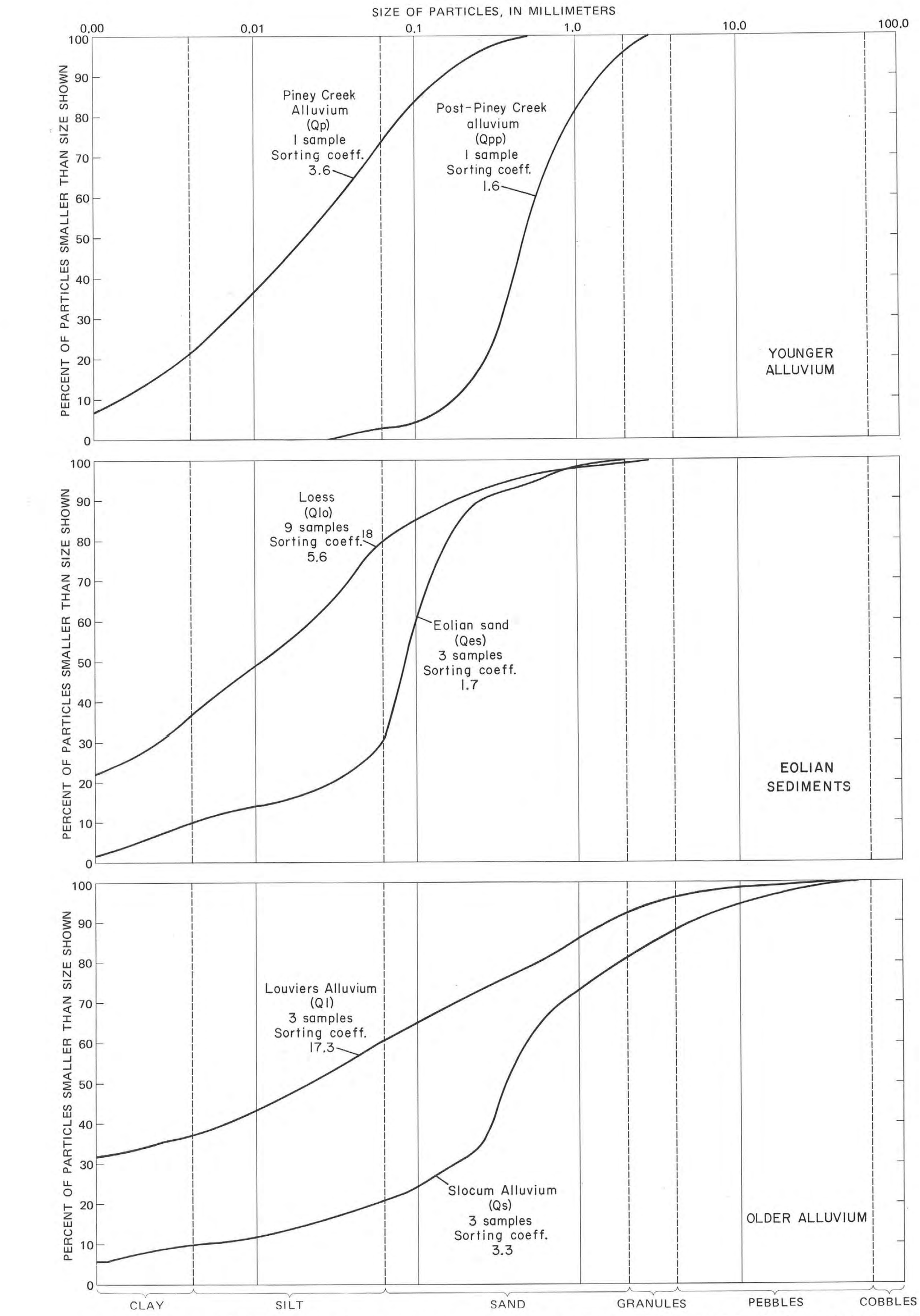

FIGURE 2.--PARTICLE SIZE DISTRIBUTION CURVES FOR SURFICIAL SAMPLES

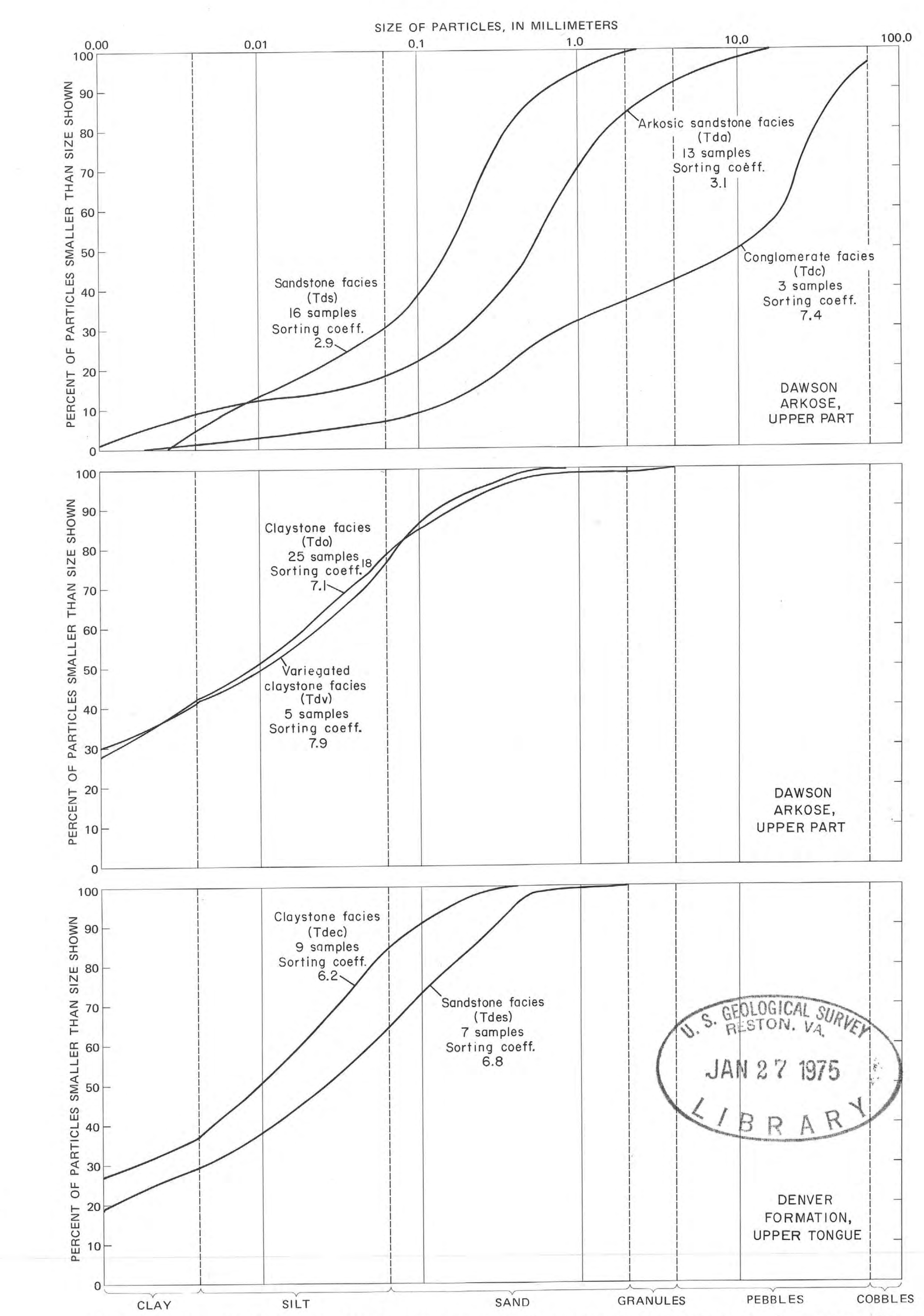

FIGURE 3.--PARTICLE SIZE DISTRIBUTION CURVES FOR BEDROCK SAMPLES

GEOLOGIC MAP AND ENGINEERING DATA FOR THE HIGHLANDS RANCH QUADRANGLE, ARAPAHOE AND DOUGLAS COUNTIES, COLORADO

By
John O. Maberry and Robert M. Lindvall

1974

For sale by U.S. Geological Survey, price $1.50 per set