TABLE 2.1 Representative Values of Porosity (after Morris and Johnson[35])

Material	Porosity, Percent	Material	Porosity, Percent
Gravel, coarse	28[a]	Loess	49
Gravel, medium	32[a]	Peat	92
Gravel, fine	34[a]	Schist	38
Sand, coarse	39	Siltstone	35
Sand, medium	39	Claystone	43
Sand, fine	43	Shale	6
Silt	46	Till, predominantly silt	34
Clay	42	Till, predominantly sand	31
Sandstone, fine-grained	33	Tuff	41
Sandstone, medium-grained	37	Basalt	17
Limestone	30	Gabbro, weathered	43
Dolomite	26	Granite, weathered	45
Dune sand	45		

[a]These values are for repacked samples; all others are undisturbed.

$$n = \text{porosity} = \frac{\text{volume of voids}}{\text{total volume}}$$

Ways of describing the subsurface material

I Porosity – (Void space)

porosity $n = \frac{\text{volume of voids}}{\text{Total volume}}$

4 types of rock porosity

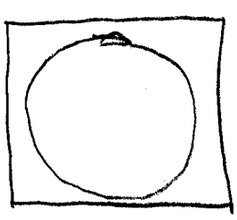
1) rocks containing intergranular voids
2) rocks containing fractures or joints (fracture tend to close with depth)
3) rocks with solution cavity openings (rocks that are soluable in water, e.g. limestone)
4) lava rocks – complex arrangement of voids due to method of formation. Can have voids similar to (1) and also tunnels similar to (3) (lava tunnels).

II Specific surface – (Friction)

specific surface is the surface area per unit weight of material

$$S.S. = \frac{\text{total surface area}}{\text{total weight}}$$

For the same porosity the right figure has a higher specific surface and therefore higher friction.



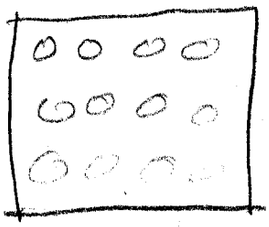


TABLE 2.3 Relation of Surface Area to Particle Size for Uniform Spheres

Diameter of Particle, mm	Soil Classification	Number of Particles per cm^3	Total Surface Area, cm^2
10	Medium gravel	1	3.14
1	Coarse sand	1×10^3	31.4
0.1	Very fine sand	1×10^6	314
0.02	Silt	1.25×10^8	1,570
0.002	Clay	1.25×10^{11}	15,700

NOTE: Rectangular packing is assumed in a cubic container 1 cm on a side so that the total volume, and weight, of spheres remains constant at $\pi/6$ cm^3.

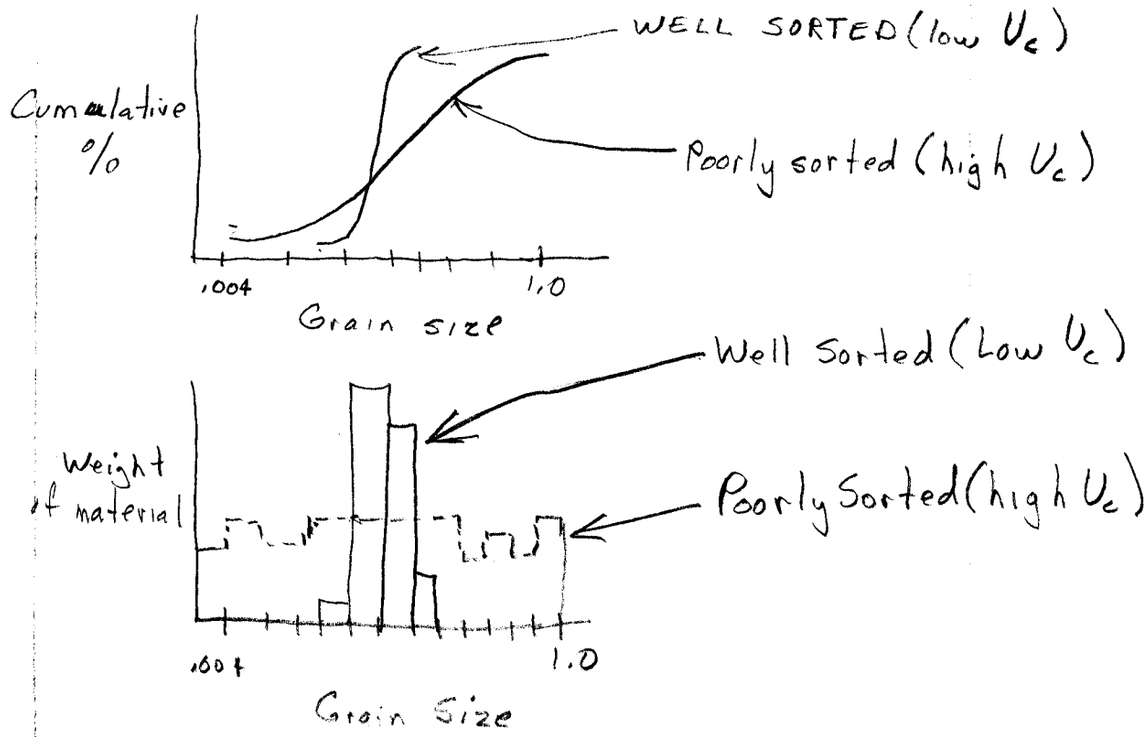
III Description of material sorting by size

Well sorted material (Poorly graded) - material with similar or uniform grain size.

Poorly sorted material - material with different grain sizes (well graded) (not uniform in size). As the range of grain sizes increases, the porosity decreases.

Uniformity coeff $= U_c = \frac{d_{60}}{d_{10}}$ { see back

$U_c = 1$ grains all the same size



d_{60} = grain diameter (in mm) corresponding to 60% passing,

d_{10} = grain diameter (in mm) corresponding to 10% passing, by weight (or mass)

Actually, the uniformity coefficient is misnamed since the smaller the number, the more uniform the gradation.

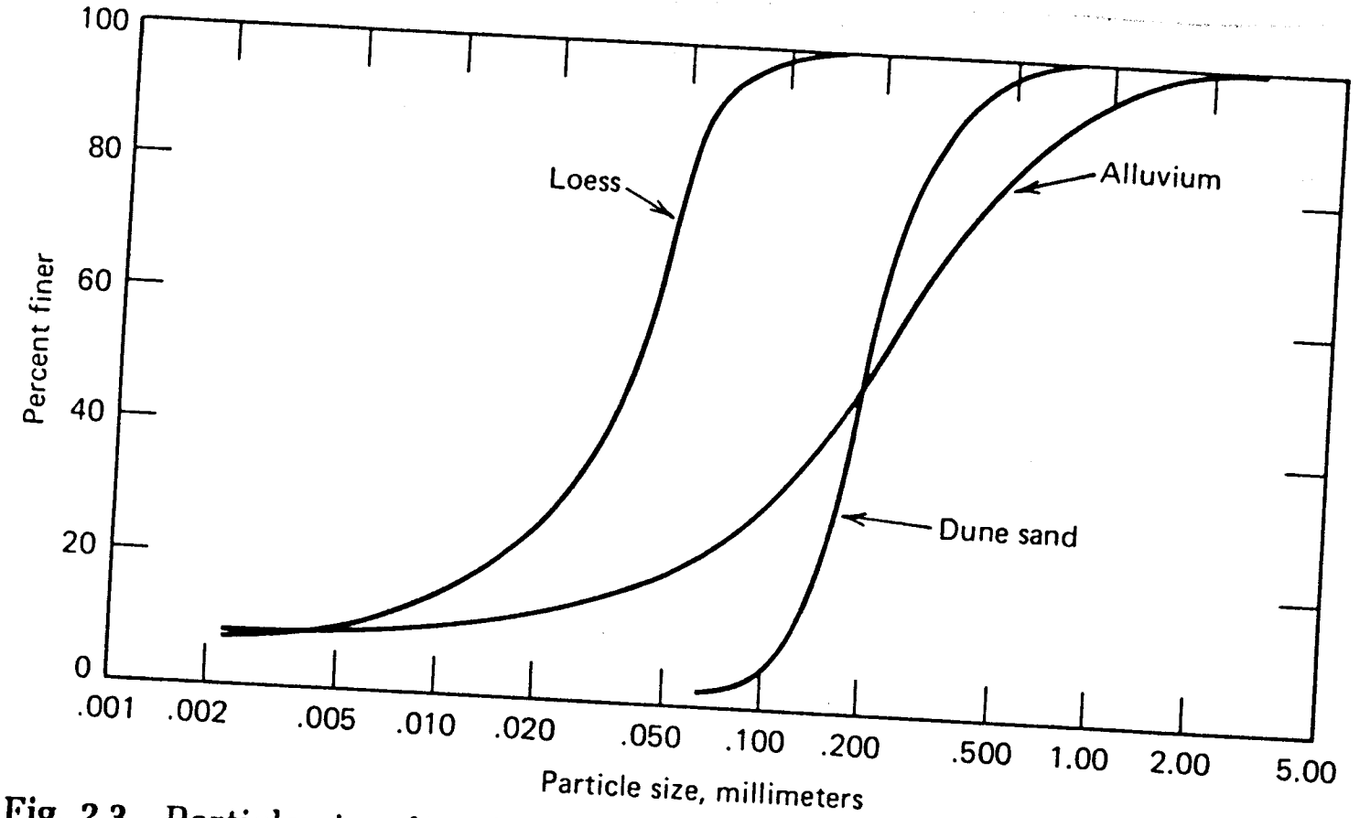


Fig. 2.3 Particle-size distribution graph for three geologic samples (data from U.S. Geological Survey).

L-2

TABLE 2.2 Soil Classification Based on Particle Size (after Morris and Johnson[35])

Material	Particle Size, mm
Clay	<0.004
Silt	0.004–0.062
Very fine sand	0.062–0.125
Fine sand	0.125–0.25
Medium sand	0.25–0.5
Coarse sand	0.5–1.0
Very coarse sand	1.0–2.0
Very fine gravel	2.0–4.0
Fine gravel	4.0–8.0
Medium gravel	8.0–16.0
Coarse gravel	16.0–32.0
Very coarse gravel	32.0–64.0

IV Shape

1) Angular - 
2) sub-angular - 
3) sub-rounded - 
4) Rounded - 
5) Well rounded, spherical - 

Material Classifications

Clay	0.004mm or less	
silt	0.004mm to 0.0675 mm	
very fine sand	0.0675	- 0.125
Fine sand	0.125	- 0.25
Medium sand	0.25	- 0.50
Coarse sand	0.50	- 1.0
Very coarse sand	1.0	- 2.0
Gravel: Granules	2.0	- 4.0
Gravel: Pebbles	4.0	- 64.0

Classification of Perosity

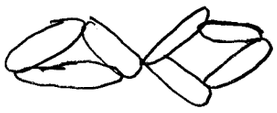
low	5% or less
medium	5% - 20%
high	20% and over

Which properties of materials affect porosity

Shape and arrangement of grains will affect the porosity.

Example arrangement

Low porosity (Why?) 

High porosity (Why?) 

Why? More void spaces per unit volume.

(18)

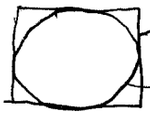
POROSITY AFFECTED BY

1) Grain shape
2) Grain arrangement
3) Grain sorting
4) Cementation
5) Interconnection of the voids (Effective porosity)
6) Degree of fracturing
7) Degree of compaction

Porosity is not dependent on grain size

A swimming pool filled with bowling balls will hold the same amount of water as one filled with marbles. (arrangement)

Proof:



Let N = number of cubes & spheres

$$n = 1 - \frac{\text{volume of the spheres}}{\text{volume of the cubes}}$$

$$n = 1 - \frac{N\, 4/3\, \pi r^3}{N\, 8r^3} = 47.64\%$$

which is <u>not</u> dependent on r (the radius). or on N (the number).

for this shape and arrangement

The above proof shows that the physical limit for porosity n_{max} is 47.64%.
The average n is 15-25%.

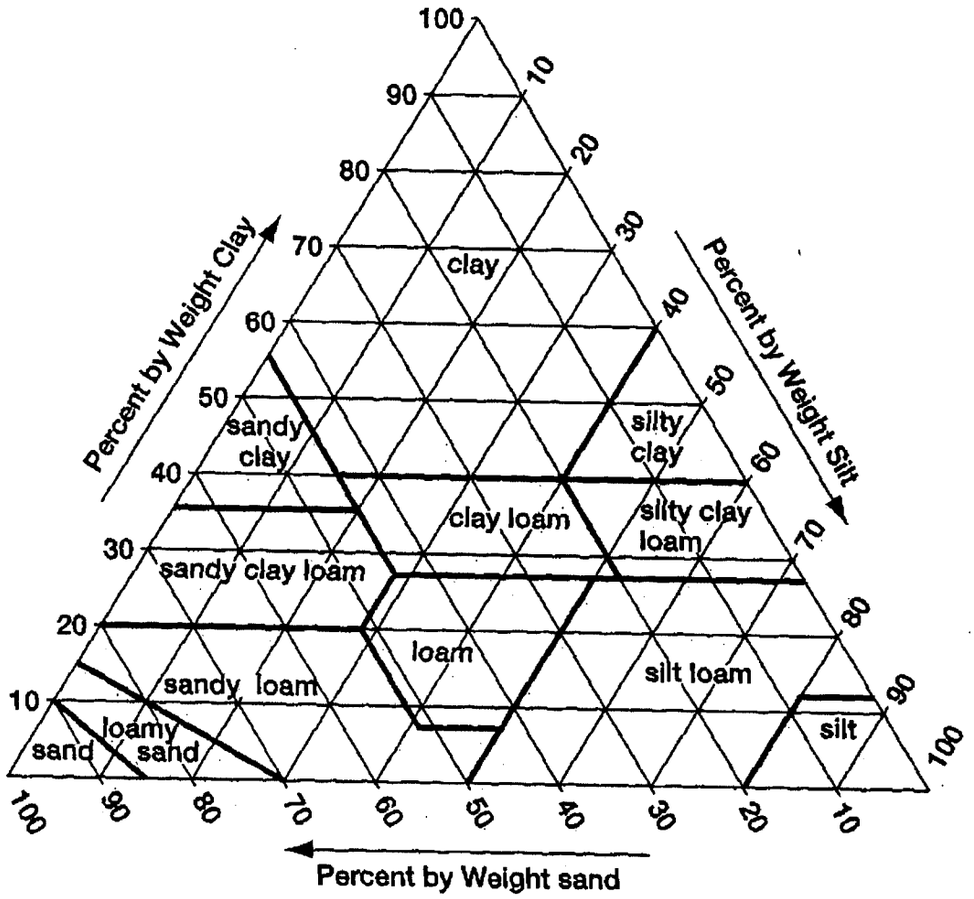


FIGURE 1.1.2 Textrue triangle, showing the fractions of clay, silt, and sand in the soil textural classes (courtesty U.S. Soil Conservation Service)