

THE USE OF PIPETTE ANALYSIS IN CLAY RESEARCH

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One of the methods used in the study of clays is the determination of the distribution of the particle sizes of both clay and non-clay mineral material. Of the several means available, pipette analysis is the most useful, because in addition to comparative size data, a sample is obtained from which a microscopic examination can be made to determine the abundance of each constituent in each size.

There is a tremendous variation in the size distribution of clays and a definite lower limit at which ordinary mechanical analyses will give reproducible results. The smallest screen size through which a clay may be wet-screened in a reasonable length of time is the No. 270, the openings of which are about 53 microns. The largest size particle for which pipette analysis will give consistent results is about 20 microns. A critical cross-section of a clay is obtained by spacing the pipette fractions at 20, 10, 5, 2, 1, and 0.5 microns. When used with the 270 mesh screen, these sizes make a very even spread of data on three cycle semi-log paper for either a cumulative or distribution curve. They include the range of clay material (less than 20 microns) set by the American Foundrymen's Association for the study of bonding clays, the U. S. Bureau of Soils upper limit of clay (five microns) and the size (two microns) below which most clay investigators agree that a clay material is predominantly clay mineral.

These sizes lend themselves to a simplified plotting of Stokes' law because the relation between each diameter is a whole number. Stokes' law, $V = 2aR^2(D_1 - D)$,

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where a = acceleration due to gravity; R = radius of particle; D_1 = Sp. G. of particle; D = Sp. G. of water at temp. used; v = viscosity of water at temp.

used; V = time to fall 1 cm.; for any one temperature may be reduced to $V = KR^2$ where K is a constant $K = \frac{2a(D_1 - D)}{v}$.

9v

At any one temperature, therefore, the sizes chosen have settling velocities which are multiples of each other. For example, the velocity varying as the square of the radius, for a particle of 20 microns diameter, $R^2 = 100$, and for a particle of 10 microns $R^2 = 25$. The ratio of the velocities is 4 to 1 or the 20 micron particle settles 4 times as fast as the 10 micron particle. Likewise, the 0.5 micron settling time is 4 times that of 1 micron, 16 times that of 2 microns, 2 microns is 100 times that of 20 microns, 0.5 microns is 100 times that of 5 microns and 1 micron is 100 times that of 10 microns.

The graph (fig. 1) was plotted from data computed at 15, 20, 25 and 30 degrees Centigrade for particles 20, 10, 5, 2, 1, and 0.5 microns in diameter assuming an effective specific gravity of 2.65. Points were first plotted for 0.5 micron using the smallest unit of the paper (1/20 inch) as one minute. The scales for each of the other sizes were then computed to fit the curve drawn through the 0.5 micron points. The following table gives values for both the large and small units of the scale for each particle size.

To obtain the settling time for any of the sizes 20, 10, 5, 2, 1, and 0.5 microns, choose in the left column the temperature best suited to the room or bath in which the analysis is to be made. Follow the horizontal line on which this temperature lies until the heavy black line of the graph is reached. Then the vertical line which passes through the graph at this point marks the time required for each particle to settle 1 cm. on each of the scales.

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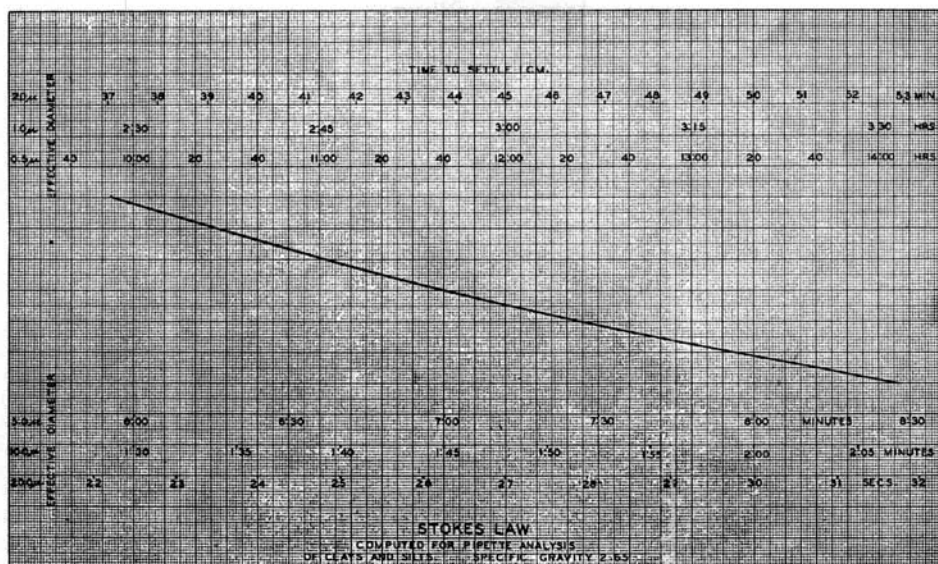


Fig. 1.

Diameter of particle	Large units	Small units
0.5	10 min.	60 sec.
1.0	2.5 min.	15 sec.
2.0	0.625 min.	3.75 sec.
5.0	6 sec.	0.6 sec.
10.0	1.5 sec.	0.15 sec.
20.0	0.375 sec.	0.0375 sec.

TABLE I

Diam. of particle	Time to settle 1 cm. at 25°C.	Depth of settling	Time of settling
0.5	11° 2' 15"	2 cm.	22° 4' 30"
1.0	2° 45' 30"	2 cm.	5° 31' 00"
2.0	41' 33"	5 cm.	3° 26' 55"
5.0	6' 37"	10 cm.	1° 6' 10"
10.0	1' 58"	10 cm.	16' 30"
20.0	8"	10 cm.	4' 8"

In practice the most suitable times for each particle size have been controlled by immersing the pipette to different depths (table 1). In this fashion, a complete analysis of all particle sizes may be finished in 24 hours, or thereabouts. By contrast, the usual hydrometer analysis in 24 hours would furnish data only to about 2 microns. A constant temperature bath agitated by bubbling air, not strong enough to shake the cylinders but enough to circulate the water, and controlled by a mercury temperature control attached to a switch tube which turns on and off a knife type electric heater will give results reproducible to one tenth of a percent on duplicates from the same sample. The most usual temperature is 25° C. Table I has been computed from fig. 1.

In interpreting pipette analysis of clays it cannot be too strongly emphasized that

the data represent only the degree to which it has been disaggregated and that it is impossible to completely break up the aggregates of a clay. In addition the particle diameters for each size measured are only equivalent sizes, that is they represent a particle, the mass and surface area of which cause it to settle at a rate equivalent to the rate at which a sphere of the same effective mass might settle.

If these two objections are taken into account and a good suspension is obtained beforehand, the data from pipette analyses will serve to compare clays which have been subjected to an identical preparation.

By using different means of disaggregation it is possible to obtain large variations in the size analyses of the same clay.