amoebae, ciliates and flagellates—when so prepared can scarcely be distinguished from living material except for the absence of movement. Chloroplasts such as those found in Euglena and the algae retain their green color, and with a nearly closed condenser the finer details, particularly of the cilia or flagella, are shown very clearly.

If permanent mounts are desired the usual staining methods may be applied, the various reagents being added to the material in the centrifuge tube. Iron haematoxylin gives splendid results after fixation with osmic acid, and with the exception of the destaining process with iron alum, the material need not be removed from the tube until it is in xylol. Chloroplasts do not seem to be affected by the various reagents, and material in balsam will remain green for weeks, after which the chloroplasts slowly fade. For finer details in such organisms it is better to bleach the chloroplasts with potassium permanganate, 1 per cent., and oxalic acid, 5 per cent., for about five minutes each before staining. Fixation in the osmic acid should be for from thirty minutes to an hour if permanent preparations are desired. This fixation, being cytoplasmic, offers an enlightening contrast to the more customary Schaudinn's fluid.

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SPECIAL ARTICLES

THE RELATION BETWEEN PROPERTIES AND CHEMICAL COMPOSITION OF SOIL COLLOIDS

IN previous publications of the Bureau of Soils it has been shown that the colloidal materials extracted from different soils may vary widely in adsorptive capacity, in heat of wetting and in chemical composition. During the past two years a series of different colloidal soil materials has been investigated for many other properties, such as size of particles, swelling, viscosity, electrical behavior and exchange of bases. The data, which are being prepared for publication, show that the colloidal materials extracted from different soils vary with respect to these properties also.

It appears, as might be expected, that the various properties of the colloid are more or less related. A colloid, for instance, which undergoes a large volume change when wetted by water, usually shows a high heat of wetting and a high adsorptive capacity for ammonia gas.

The properties of different soil colloids appear also to be related to their chemical composition. The major constituents of the soil colloidal material are silica, alumina and iron, and, in the case of many colloids, the properties vary fairly regularly with the contents of these major constituents as expressed by the molecular ratio of silica to alumina plus iron.

An example of interrelationship between properties of the colloid and of parallelism between properties and chemical composition is shown in Table I. In this table a series of colloids extracted from different soils is arranged in ascending order of the ratio, silica to alumina plus iron. The heat (in small calories) evolved by these colloids on immersion in water and the ammonia gas adsorbed are shown in columns 3 and 4. In order to make the relationship more apparent and to bring out individual exceptions, the data of columns 2, 3 and 4 are expressed relatively in columns 5, 6 and 7. The lowest value in each series of determinations is placed at zero and the highest value at 100. By this procedure the different orders of magnitude of the three series of data are equalized; also the amplitudes of variation between the lowest and highest determinations are brought to 100 in each series. Most of the data in the table are taken from previous publications of this Bureau.[1, 2, 3]

It is apparent that on the whole there is a close parallelism between the heats of wetting, ammonia adsorptions and the silica ratios of the different colloids. Coefficients of correlation[4] for these three series of values are as follows: heat of wetting with ammonia adsorption 0.99, heat of wetting with silica ratio 0.93 and ammonia adsorption with silica ratio 0.90. The high coefficients of correlation, together with the fact that correspondence between the lower relative values in columns 5, 6 and 7 is about as good as correspondence between the higher relative values, indicate that the three series of values are approximately straight line functions of one another.

The correlation between heat of wetting and ammonia adsorption may be expected to hold fairly well for practically all soil colloids. But the correlation between heat of wetting (or ammonia adsorption) and $\frac{SiO_2}{Al_2O_3 + Fe_2O_3}$ is probably subject to

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[1] Anderson, M. S., "The heat of wetting of soil colloids," *Jour. Agr. Research,* 28: 927–935 (1924).

[2] Gile, P. L., *et al.,* "Estimation of colloidal material in soil by adsorption," U. S. Dept. Agr. Bul. 1193 (1924).

[3] Robinson, W. O., and Holmes, R. S., "The chemical composition of soil colloids," U. S. Dept. Agr. Bul. 1311 (1924).

[4] Calculated according to the formula given by Tolley, H. R., and Mendum, S. W. "A method of testing farm-management and cost-of-production data for validity of conclusions," U. S. Dept. Agr. Circular 307 (1924).

TABLE I

HEAT OF WETTING, AMMONIA ADSORPTION AND $\frac{SiO_2}{Al_2O_3+Fe_2O_3}$ RATIO OF COLLOIDAL MATERIALS ISOLATED FROM DIFFERENT SOILS

Source of colloidal material	Molecular ratio $\frac{SiO_2}{Al_2O_3+Fe_2O_3}$	Heat of wetting per gram of colloid	NH_3 adsorbed per gram of colloid	Relative values		
				$\frac{SiO_2}{Al_2O_3+Fe_2O_3}$	Heat of wetting	NH_3 adsorbed
		Calories	Grams			
Cecil subsoil	1.20	4.5	0.0192	0	0	3
Cecil soil	1.34	6.2	0.0230	7	13	12
Chester soil	1.77	7.2	0.0293	28	21	26
Norfolk subsoil	1.84	6.0	0.0295	32	11	27
Huntington soil	1.86	8.3	0.0319	33	29	32
Sassafras subsoil	1.89	9.8	0.0340	34	40	37
Hagerstown subsoil	1.89	7.9	0.0299	34	26	28
Susquehanna subsoil	1.98	5.3	0.0177	40	6	0
Miami subsoil	2.66	11.8	0.0358	72	56	41
Marshall soil	2.82	14.2	0.0536	80	74	82
Stockton soil	2.85	16.3	0.0617	81	90	100
Wabash soil	3.16	17.6	0.0614	97	100	99
Sharkey soil	3.23	16.3	0.0609	100	90	98

some marked exceptions. In the case of the Susquehanna subsoil colloid there is poor agreement between the heat of wetting and the silica ratio, although the agreement between heat of wetting and ammonia adsorption is very good. A correlation of the silica ratio with the heat of wetting or adsorption would not be expected to hold for colloids from peat soils, which are composed chiefly of organic matter and contain comparatively little silica, alumina and iron. Furthermore, colloids exceptionally low in silica and high in alumina and iron may as a class be exceptions to this correlation. For instance, a colloid containing only 15 per cent. of silica with a $\frac{SiO_2}{Al_2O_3+Fe_2O_3}$ ratio of 0.55 has recently been isolated from a deep tropical subsoil. The heat of wetting of this sample is 8 calories, or approximately the magnitude usually given by colloids having a silica ratio of about 1.9.

The $\frac{SiO_2}{Al_2O_3+Fe_2O_3}$ ratio is not the only expression of chemical composition that shows a parallelism to the properties of the colloid. It was pointed out in a recent bulletin of this Bureau[5] that the colloids high in silica were usually low in alumina, high in monovalent and divalent bases and low in combined water. A fairly good correlation obtained between the ratio, $\frac{SiO_2}{Al_2O_3+Fe_2O_3}$, and the ratio $\frac{SiO_2}{CaO+Na_2O}$ for a series of soils. In view of these relationships, it follows that other chemical constituents beside the silica ratio correlate with the properties of the colloid. For instance, some properties appear to be closely related to the percentage of calcium or to the total exchangeable monovalent and divalent bases. Joseph and Hancock[6] have suggested that the properties of colloids from soils and clays probably bear a general relationship to the $\frac{SiO_2}{Al_2O_3}$ ratio, the more plastic clays having the higher ratios.

A knowledge of the interrelationships of the properties of soil colloids and of the correlation between chemical composition and properties is of practical value in supplying a basis for predicting the general behavior of the colloids without extensive physical tests or complete chemical analyses. Similar relationships between properties and chemical composition doubtless obtain for the colloidal materials of ceramic clays and the recognition of these relations should be important in the ceramic industries.

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CONTINUOUS REPRODUCTION OF MICRO-ORGANISMS IN SYNTHETIC MEDIA

THE controversies and work of Pasteur, von Liebig, Mayer and Nageli suggest that yeast may fail of

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[5] Robinson, W. O., and Holmes, R. S., p. 16, *l. c.*

[6] Joseph, H. F., and Hancock, J. S., "The composition and properties of clay," Trans. Chem. Soc. 125: 1888–1895 (1924).