The assumptions which are made with regard to the flow régime are: (1), The wetting front is sharply defined and the water pressure is known at some point behind the wetting front, and (2), the soil moisture content behind the wetting front does not change appreciably with time and is close to saturation.

If Q is the volume flow per unit time out of the cavity, then as the wetting front moves radially outward:

$$Q = S4\pi r^2 dr/dt \quad (1)$$

where S is the change in moisture content expressed as the volume of water change per unit volume of soil. The $4\pi r^2$ term represents the circumferential area of the wetting front and this is multiplied by dr to give the volume of soil. An alternative expression for the flow can be obtained by a consideration of the pressure distribution around a spherical source. The equation for the flow per unit time is given by:

$$Q = [k4\pi(p_w - p_c)]/(1/r_w - 1/r_c) \quad (2)$$

Setting these two equations equal and solving for the hydraulic conductivity k , we have, after introducing the boundary conditions:

$$k = [1/(t_2 - t_1)] \{ (1/3)S(r_2^3 - r_1^3)/r_w(p_w - p_c) - 1/2[S(r_2^2 - r_1^2)/(p_w - p_c)] \} \quad (3)$$

where p_c is the pressure head behind the wetting front, p_w is the average pressure head in the cavity, r_w is the equivalent radius of the cavity and $t_2 - t_1$ is the time required for the wetting front to travel from r_1 to r_2 .

The above equation is used to calculate the hydraulic conductivity following the procedure outlined below. Two measurements are needed: the rate of flow from the cavity and the time for the wetting front to move from r_1 to r_2 as shown in Fig. 1. The change in moisture content, S , is calculated by $S(r_2 - r_1) = Q(t_2 - t_1)/(4\pi r^2)$, where r is taken as the average of r_1 and r_2 . The progress of the wetting front from r_1 to r_2 is measured electrically.

A laboratory experiment was performed to test the validity of the assumptions used in the development of the theory. The experiment was performed in a sector tank filled with a Columbia fine sandy loam soil. Pressure measurements were made with tensiometers located at various points in the tank. The results of the tank measurement indicate that the assumptions are reasonable and the values of hydraulic conductivity obtained in the tank indicate that the method can be used to get an approximate value of hydraulic conductivity in the field.

The method is at present being developed in the field and as additional information is obtained a further report will be made.

J. N. LUTHIN

Department of Irrigation,
University of California,
Davis, California.

¹ Luthin, J. N., and Kirkham, D., *Soil Science*, **68**, 349 (1949).

Nature of Sulphate Retention by Acid Soils

CERTAIN soils containing oxides which occur in tropical and subtropical regions are known to retain an appreciable amount of sulphate when equilibrated with dilute solutions of sulphate salts^{1,4}. In our earlier work we found that the cation and anion are

held in about equivalent amounts, with an increase in retention occurring as the pH was lowered or the salt concentration was increased. So far as we are aware no satisfactory explanation for all the phenomena observed has yet been given.

Recently we have found that the amount of sulphate which is held by an acid red soil increases with time of equilibration up to eight weeks (the longest period studied). Sulphate was added as K_2SO_4 and the amount retained was measured in two ways. In the first, the K_2SO_4 was labelled with sulphur-35 and its disappearance from solution was recorded. In the second, the cations in solution were measured and their sum assumed to be equal to the sulphate in solution. The first method has the disadvantage that isotopic exchange with native soil sulphate occurs and makes the results higher than the true values. The second suffers from lack of precision. Taken together, however, they show about the same trend in the retention of sulphate with time. As can be seen from Table 1, the greatest increase in sulphate held occurred during the first 24 hr.

Table 1. EFFECT OF TIME ON THE RETENTION OF SULPHATE FROM 0.01 N K_2SO_4 BY CECIL SOIL

Equilibration time	Sulphate retained (m.equiv./100 gm.)	
	By sulphur-35	By cation sum
1 hr.	1.50	0.42
24 hr.	2.20	1.74
1 wk.	2.40	2.04
2 wk.	3.24	1.92
4 wk.	3.60	2.02
8 wk.	—	2.38

It has been found² that the hydrolysis of exchangeable aluminium and the formation of hydroxy-aluminium compounds proceeds at a greater rate in soil systems to which a salt has been added. In acid red soils the sulphate can exchange with some of the hydroxyl ions on the hydroxy-aluminium (or iron) polymers. The overall reaction is described as follows:

The replacement of hydroxyl groups from the hydroxy-aluminium groups results in the neutralization of hydrogen ions from the hydrolysis of exchangeable aluminium. Similar reactions also occur with salts of chloride and nitrate.

A reaction of this general form explains the increase in sulphate retention with increasing concentration and decreasing pH since under both these conditions hydroxyl ions would be replaced more easily. The increase in retention of sulphate with time is explained by the hydrolysis of exchangeable aluminium to a dihydroxy-aluminium species³ and the subsequent neutralization of the hydrogen ions thus formed by replaced hydroxyl ions. This reaction provides sites on which both potassium and sulphate ions can be held.

MONICA LIU
G. W. THOMAS

Agronomy Department,
Virginia Polytechnic Institute,
Blacksburg, Virginia.

¹ Berg, W. A., and Thomas, G. W., *Soil Sci. Soc. Amer. Proc.*, **23**, 348 (1959).

² Hsu, P. H., and Rich, C. I., *Soil Sci. Soc. Amer. Proc.*, **24**, 21 (1960).

³ Ragland, J. L., and Coleman, N. T., *Soil Sci. Soc. Amer. Proc.*, **24**, 457 (1960).

⁴ Thomas, G. W., *Soil Sci. Soc. Amer. Proc.*, **24**, 329 (1960).